ESSAYS ON TARIFF FORMATION

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Abstract

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In an era of enhanced trade liberalization the study of tariff policy and formation assumes increasing importance. This dissertation explores tariffs under three different contexts.

First, we examine the effect of technology on the choice of external tariffs by trading nations. The literature on tariffs usually assumes that trading partners are symmetric in key fundamental parameters such as factor endowments, technology, preferences, policy and institutional frameworks. This is done in the interest of tractability given the complexity of the problems addressed. There thus exists scope for research on the impact of inter-country differences in fundamentals on policy preferences. We examine the relationship between a key asymmetry, namely technology, and tariff selection in a dual general equilibrium model along the lines of Dixit and Norman (1980). We find that it is possible to rank tariffs by comparing the compensated price elasticity of the import demand function. An expression for this elasticity in terms of a technological shift parameter is found and tariffs ranked under various specifications of the parameter. An empirical exercise using a cross-sectional sample of 42 countries finds some evidence of an inverse relationship between technology and tariffs.

Second, we study reciprocal trade liberalization in a two country setting that allows for asymmetry in country size. The analysis draws on Furusawa (1999) wherein it is suggested that as long as status-quo tariffs are invariant during the negotiation process, the country with the higher status-quo tariff rate benefits more from the negotiation and vice-versa. We formalize this insight by explicitly introducing country size and asymmetric status-quo tariffs in a Rubinstein-type bargaining model. Our findings indicate that a large country will gain more from tariff negotiations regardless of the patience exhibited by the smaller country during the bargaining process.

Third, we use two new measures of openness, namely the Trade Restrictiveness Index and the Mercantile Trade Restrictiveness Index (Anderson and Neary, 1996, 2003) to empirically examine the relationship between a country's size and outward orientation. We find that the negative relationship between country size and openness reported in the literature holds when these two measures are employed.

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Tariff Preferences and Technology

Abstract

We examine the relationship between technology and tariff selection in a dual general equilibrium model, along the lines of Dixit and Norman (1980). We find that it is possible to rank tariffs by comparing the compensated price elasticity of the import demand function. We find an expression for this elasticity in terms of a technological shift parameter and rank tariffs under various specifications of the parameter. An empirical exercise finds some evidence of an inverse relationship between certain measures of technology and tariffs.

1 Introduction

The theoretical literature on tariff formation and evolutionary tariff games[1] often features the *a-priori* supposition that trading partners are symmetric in terms of key fundamental parameters such as factor endowments, technology, preferences, policy issues and institutional frameworks. The adoption of this strategy is understandable on grounds of tractability given the complex nature of the problems addressed. Nonetheless, it is an immutable fact that in the real world trade occurs between partners which have dissimilarities in the aforesaid parameters and that these dissimilarities affect trade policy in non-trivial ways. Thus, there exists a broad scope for research on the nature of the impact of inter-country differences in fundamentals on policy preferences. This paper is an attempt to analyze the effect of a key fundamental, namely technology, on the choice of external tariffs by trading nations.

A fairly extensive literature in the area of technology policy exists. Broadly speaking, the literature encompasses two different strands – one examines the impact of technology on endogenous growth while the other looks at technology within the framework of strategic trade policy. While the relevance of the latter to our present effort is clear and provides the motivational impetus for the subsequent analysis, the former has important bearings too. In the interests of providing a fuller introduction to our main topic we will enumerate some of the more germane insights from endogenous growth theory first.

[1] Please see, for example, Bac and Raff (1997)

Pioneering work by Grossman and Helpman (1991) and by Rivera-Batiz and Romer (1991 a, b) have focused on the link between international trade integration and the associated changes of sectoral specialization patterns on one hand and prospects for long-run growth on the other[2]. The essence of their conclusions is as follows: international trade patterns in high-technology markets are determined by comparative advantage. The sources of these advantages are often the result of countries' investment in research and development (R&D), i.e., investment in knowledge creation. If the knowledge thus created is global, i.e., if the degree of (technological) knowledge spillover is universal so that competitors in all countries have access to the common knowledge pool, there will be no effects on trade patterns. In such circumstances, national technology policy makes little sense because any new knowledge that it engenders will diffuse outside the country without giving domestic producers any meaningful and persistent advantage over foreign competitors.

If, on the other hand, knowledge spillovers remain geographically concentrated and thus essentially national in scope, a cumulative process of 'national' learning might set in and lead to the establishment of a competitive wedge between the respective national industry and the rest of the world. In these circumstances, a national technology policy might be justified on virtuous grounds. The modern theories of endogenous growth recommend public support of R&D instead of protectionist measures such as production subsidies or external tariffs. These measures are advocated not to minimize static allocative losses but to avoid

[2] Please see the excellent survey in "Conflict and Cooperation in National Competition for High-Technology Industry", National Academy Press, Washington , D.C. 1996

resource competition for skilled labor that may be used in both manufacturing and research. For example, production subsidies or tariff protection of high-tech production may induce highly qualified scientific personnel to migrate from research into production thereby increasing the cost of R&D and reducing the country's growth potential.

The pioneering work on strategic trade theory can be attributed to Brander and Spencer (1983, 1985) and Dixit and Kyle (1985). Their research has focused on the international rivalry for monopoly rents in world markets that operate under conditions of highly imperfect competition, usually involving only a few producers from different countries. A fairly straightforward case for government intervention in the form of so-called strategic trade policy is made. By means of subsidies or tariff protection to 'newcomers' the government may turn potential competitors into actual ones, breaking up the (quasi) monopolistic market position of the dominant foreign producer(s) and shifting at least some of the monopoly rents from one country to another. If the gain in rent exceeds the subsidy costs or losses caused by the tariff wedge, the policy stance pays off from a national point of view.

Williamson (2003) examines tariff policy from a historical perspective. By examining a set of world tariff facts for 150 years between 1789 and 1938 he finds that tariff policy was driven essentially by revenue considerations and strategic tariff behavior. He noted that the Stolper-Samuelson explanation for tariff formation – the granting of protection to scarce factors at the expense of abundant factors – satisfactorily explained tariff policy prior to the 20th century, while the well known infant industry argument assumed a prominent role in tariff setting thereafter. In addition, considerations of geography, home market size, world economic environment, trading partner behavior, tariff autonomy and "gunboat" diplomacy all played their part as well.

The literature mentioned above, while greatly illuminating, by and large treats policy instruments such as tariffs and subsidies as exogenously determined. Governments identify areas of economic activity that are deemed to be beneficial or crucial for positive long-term economic performance and grant support accordingly. Absent from the literature seems to be any examination of the dependence of policy instruments on the nature of technology per-se. This is puzzling given that technology evolves over time and has a natural bearing on GDP. Any consideration of trade policy ought to take this into account. Furthermore, a natural corollary of the infant industry argument mentioned above is that when such industries "grow up" i.e. are deemed to be able to survive on a competitive footing, their tariff protections should either cease or diminish. Given that technological evolution (and technology could be 'home-grown' or imported) could lead to such an outcome the idea of a link between technology and tariff policy is a conceptually sound one. Yet scarce literature on this aspect exists.

Claro[3] does, in fact, consider a putative link between labor-saving technological change and changes in tariff structure and rise in international wage differences in a dual sector model[4]. However, he fails to arrive at any definitive conclusion regarding the link within the framework of his model.

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[3] Sebastian Claro, "Tariffs, Technology and Global Integration", unpublished mimeo, Universidad Catolica de Chile

[4] A model with a capital intensive sector and a labor intensive sector.

Another strand of literature examines tariff delegation decisions within customs unions. Lipsey (1970) argued that the common external tariff adopted by customs unions should be chosen to maximize the joint welfare of union members provided intra-union transfers are feasible. In the absence of such feasibility, each member of the union should be allowed to set an external policy to maximize its own welfare (Riezmann, 1985). In a notable contribution by Gatsios and Karp (1995) it is demonstrated that it might be in a union member's best interest to actually delegate authority to set external policy to another member (usually the biggest). Following on, Syropoulos (2002a) examines tariff preferences in customs unions based upon a Heckscher-Ohlin (HO) approach. Within the context of a general neo-classical trade model, he first shows that for any two customs union members trading with the rest of the world (ROW), the least aggressive member[5] is the country with the largest compensated price elasticity of import demand. The HO model is then used to characterize the dependence of this elasticity on relative factor endowments and technology.

Our approach would be similar. First we will set up a general equilibrium trade model incorporating technology in the revenue function in order to obtain some comparative static results. This will be followed by refinements wherein the parameter of interest is characterized using specific functional forms. Unlike Claro, we are able to establish a connection between technology and tariff levels.

We also carry out an empirical exercise to examine the relationship between tariffs and technology. We expect that an inverse relationship between the two

[5] Aggression, in this context, refers to the propensity of a trading partner to deviate from a common external tariff.

should exist i.e. the higher the "level' of technology, the lower the corresponding tariff rates. Evidence supporting this hypothesis is found.

The basic framework of the neo-classical trade model along with comparative static analysis is presented in Section 2. Section 3 presents refinements and discussions, the empirical exercise is presented in Section 4 and Section 5 concludes.

2 General Framework

In order to examine how technology affects tariff formation we adopt the basic model of Syropoulos and incorporate a technological "shift" parameter in the revenue function along the lines of Dixit and Norman. To this end we assume a world of two countries of equal size, labeled 1 and 2, that produce, consume and trade two final goods (also labeled 1 and 2) using an inelastically supplied vector of factor inputs $\mathbf{v}^i$. Consumer tastes are identical and homothetic, all markets are competitive, there are constant returns to scale and no domestic distortions. For concreteness we simply assume that country i has a comparative disadvantage in good i and thus imports good i. Let $r^i(p^i,\theta^i,\mathbf{v}^i)$ and $e^i(p^i,u^i)$ denote country i's revenue (GDP) and expenditure functions, respectively. Here, p^i is the domestic relative price of country i's importable measured in terms of its exportable, θ^i is a shift parameter capturing technology (which can take the form of a factor intensity ratio for example) and u^i is the average welfare in country i. Let τ^i be country i's ad-valorem import tariff and let world or external prices be denoted by π^i ($\pi^1=1/\pi^2$) [6]. The

[6] Indeed, under our assumed trade patterns $p^1 = p_1^1 / p_2^1$, $p^2 = p_2^2 / p_1^2$ where subscripts index goods, thus $\pi^1 = 1/\pi^2$.

assumption of equal size implies that per-capita endowments in the two countries are the same which allows us to suppress the vector of factor inputs from the revenue (GDP) functions. For future use, we let $\alpha_D^i = p^i e_{pu}^i / e_u^i$ represent country i's expenditure share on its importable and $\eta_D^i = p^i e_{pp}^i / e_p^i$ the absolute value of its compensated (i.e. holding utility and factor endowments constant) price elasticity of demand for the importable good. We can define the fraction of GDP contributed by the import competing industry and the price elasticity of supply for the same product as $\alpha_S^i = p^i r_{p\theta}^i / r_\theta^i$ and $\eta_S^i = p^i r_{pp}^i / r_p^i$ respectively.

We can now formulate a tariff distorted equilibrium described by the following set of equations:

$$p^i = (1+\tau^i)\pi^i \qquad i = 1, 2 \qquad (1)$$

$$e^i(p^i, u^i) = r^i(p^i, \theta^i) + \tau^i \pi^i m^i \qquad i = 1, 2 \qquad (2)$$

$$m^i = e_p^i - r_p^i \qquad i = 1, 2 \qquad (3)$$

$$\pi^i m^i = m^j \qquad i \neq j = 1, 2 \qquad (4)$$

The equations in (1) relate internal and external relative prices. Those in (2) represent budget constraints – a country's average expenditure is equal to its average revenue (GDP) plus per-capita tariff revenues. The equations in (3) describe each country's average import demand function. The set of equations in (4) represent the balanced budget and market clearing conditions (by Walras' law one of the equations in (4) is redundant). In order to ensure the existence of a competitive equilibrium we rule out non-convex isoquants and transformation frontiers as well as increasing returns to scale. In other words, the set of all technologically feasible input-output vectors are convex. Additionally, each consumer has preferences with convex indifference curves. We further assume that the revenue function is fully differentiable – a crucial assumption as it guarantees uniqueness of the trade price and utility levels. Non-differentiability may arise if there are more goods than factors and we assume away this pathology.

The set of equations described above forms the basis of a great deal of analysis in international trade theory. The theoretical formulation of the system is fully discussed in Dixit and Norman (1980). As has already been mentioned, a version of it is used by Syropolous (2002a) in his study of tariff preferences in customs unions, he also uses another version of it in examining optimum tariffs, retaliation and country size (2002b). The model is thus "flexible" in the sense that it can be amended to analyze different trade issues.

Turning to the model we note the following:

Clearly, $m^i = m^i(\pi^i, \tau^i)$, total differentiation yields

$$dm^i = m^i_{\pi^i} d\pi^i + m^i_{\tau^i} d\tau^i \tag{5}$$

We can define the direct (uncompensated) price elasticity of import demand as $\varepsilon^i \equiv -\frac{\partial m^i}{\partial \pi^i}\frac{\pi^i}{m^i}$, rewrite (5) as $dm^i = \frac{\partial m^i}{\partial \pi^i} \cdot \frac{\pi^i}{m^i} \cdot \frac{m^i}{\pi^i} d\pi^i + \frac{\partial m^i}{\partial \tau^i} \cdot \frac{\tau^i}{m^i} \cdot \frac{d\tau^i}{\tau^i} m^i$ and divide throughout by m^i to obtain

$$\hat{m}^i = -\varepsilon^i \hat{\pi}^i - \beta^i \hat{\tau}^i \tag{6}$$

where we define $\beta^i \equiv -\frac{\tau^i}{m^i}\frac{\partial m^i}{\partial \tau^i}$, and a hat (^) over a variable denotes percentage change. Equation (6) simply tells us that (ceteris paribus) country i's import volume is inversely related to its tariff or the world price. Total differentiation of (4) yields

$$\begin{aligned} dm^j &= \pi^i dm^i + m^i d\pi^i \\ d\pi^i &= \frac{dm^j}{m^i} - \pi^i \hat{m}^i \qquad\qquad i \neq j = 1,2 \\ \hat{\pi}^i &= \hat{m}^j - \hat{m}^i \end{aligned} \tag{7}$$

Utilizing (6) in (7) we get

$$\begin{aligned} \hat{\pi}^i &= -\varepsilon^j \hat{\pi}^j - \beta^j \hat{\tau}^j + \varepsilon^i \hat{\pi}^i + \beta^i \hat{\tau}^i \\ -\hat{\pi}^i(\varepsilon^i - \varepsilon^j \frac{\hat{\pi}^j}{\hat{\pi}^i} - 1) &= -\beta^j \hat{\tau}^j + \beta^i \hat{\tau}^i \\ -\hat{\pi}^i(\varepsilon^i + \varepsilon^j - 1) &= -\beta^j \hat{\tau}^j + \beta^i \hat{\tau}^i \qquad\qquad i \neq j = 1,2 \\ \hat{\pi}^i &= -\frac{\beta^i}{\Delta}\hat{\tau}^i + \frac{\beta^j}{\Delta}\hat{\tau}^j \end{aligned} \tag{8}$$

where $\Delta \equiv \varepsilon^i + \varepsilon^j - 1 > 0$ must be fulfilled for (8) to hold, but this is just the general Marshal – Lerner condition for market stability. This condition together with the assumptions mentioned above, together guarantee the existence of a unique and stable equilibrium. Equation (8) tells us that an increase in a country's import tariff causes its terms of trade to improve and the terms of trade of its partner to deteriorate.

Since we have assumed identical and homothetic tastes, we may write the expenditure function $e^i(p^i, u^i)$ as $e(p^i)\phi(u^i)$, $\phi' > 0$ for country i. With ordinal preferences we can assume $\phi'(u^i) = u^i$. This allows us to define country i's per-capita expenditure function in units of its exportable as $e^i u^i$ where $e^i \equiv e(p^i)$. Similarly defining the revenue function, the average import demand function can be written as $m^i = e^i_p u^i - r^i_p \theta^i$. Furthermore, these assumptions allow us to rewrite α^i_D and α^i_S as $p^i e^i_p / e^i$ and $p^i r^i_p / r^i$, respectively. Taking these modifications into account enable us to obtain the following expressions for m^i and u^i from equations (1) – (3).

$$m^i = \frac{r^i(\alpha^i_D - \alpha^i_S \theta^i)}{p^i(1 - T^i \alpha^i_D)} \qquad i = 1, 2 \tag{9}$$

$$u^i = \frac{r^i(1 - T^i \alpha^i_S \theta^i)}{e^i(1 - T^i \alpha^i_D)} \qquad i = 1, 2 \tag{10}$$

where $T^i = \dfrac{\tau^i}{1 + \tau^i} \in [0,1)$

It is notable that a country's per capita imports and utility can both be affected by technology. More pertinently, equation (9) lays out the condition for country i to import good i. Since $1 - T^i \alpha^i_D > 0$, as long as r and p remain finite, importation will take place if $\alpha^i_D > \alpha^i_S \theta^i$ i.e. country i's expenditure share on good i

exceeds industry i's GDP share. Turning to equation (10), we see that the condition $0 < 1 - T^i \alpha_S^i \theta^i < 1$ will ensure diversification in production.

In order to investigate the effect of endogenous variables on welfare we derive several comparative static results from the above system. In what follows some superscripts have been omitted to avoid clutter and as usual a hat (^) over a variable denotes percentage change (i.e. $\hat{x} = dx / x$).

Totally differentiating (2) and using (1) and (3) we obtain:

$$e_u^i \, du^i = \pi^i m^i (-\hat{\pi}^i + \tau^i \hat{m}^i) + r_\theta^i d\theta^i \tag{11}$$

The first two terms inside parenthesis are terms of trade and volume of trade effects, respectively. The last term represents the marginal contribution of technology. It is not surprising that this contribution is positive[7].

Totally differentiating (3) we obtain:

$$\hat{m}^i = \left(\frac{p^i e_{pp}^i - p^i r_{pp}^i}{e_p^i - r_p^i} \right) \hat{p}^i + \frac{1}{(1+\tau^i)\pi^i m^i} \left(\frac{p^i e_{pu}^i}{e^i{}_u} \right) e_u^i du^i - \frac{1}{(1+\tau^i)\pi^i m^i} \left(\frac{p^i r_{p\theta}^i}{r^i{}_\theta} \right) r_\theta^i d\theta^i \tag{12}$$

[7] Actually, it is possible to conceive of a situation when the net contribution of technology to overall welfare might be negative. Technology may improve outputs in the export sector so much so that the terms of trade deteriorate. This is of course the classic case of immiserizing growth. While the literature on this topic is scant, Sawada (2003) provides empirical evidence of the existence of immiserizing growth in 28 countries between 1950 and 1988. Hamada and Itawa (1984) report how large increases in the price of oil can result in immiserizing growth and describe a situation where the gains from an improvement of production technology is outweighed by the loss from deteriorating terms of trade. Indeed, this is an actual instance of immiserizing growth induced by technological change.

Defining $\eta^i \equiv -p^i(e^i_{pp} - r^i_{pp})/(e^i_p - r^i_p)$ as the compensated price elasticity of the import demand function, utilizing (11) in (12) and rearranging terms we obtain

$$\hat{m}^i = -\frac{\eta^i \hat{p}^i}{1 - T^i \alpha^i_D} - \frac{\alpha^i_D/(1+\tau^i)}{1 - T^i \alpha^i_D}\hat{\pi}^i + \frac{r^i_\theta d\theta^i (\alpha^i_D - \alpha^i_S)}{(1 - T^i \alpha^i_D) p^i m^i} \tag{13}$$

With little loss of generality we can substitute (9) for m^i in (13) in order to get:

$$\hat{m}^i = -\frac{\eta^i \hat{p}^i}{1 - T^i \alpha^i_D} - \frac{\alpha^i_D/(1+\tau^i)}{1 - T^i \alpha^i_D}\hat{\pi}^i + \left(\frac{\alpha^i_D - \alpha^i_S}{\alpha^i_D - \alpha^i_S \theta^i}\right)\frac{r^i_{\theta^i}}{r^i} d\theta^i \tag{14}$$

The first term on the right hand side of (14) shows the production and substitution effects of an increase in price which is negative overall. The second term on the right hand side can be construed as an income effect. A fall in the world price will cause the volume of imports to increase as a consequence of the normality of demand. The third term captures the effect of technology on imports. We recall that θ is a shift parameter which captures the state of technology. To examine its relationship with imports we must specify the precise nature of the technology. A technological evolution may result in altered levels of domestic production of goods 1 and 2 with commensurate effects on imports. Of course, the precise effect on net imports will depend on the elasticity of import demand.

Substituting (14) in (11) and simplifying the resulting expression we obtain:

$$e_{u^i}^i du^i = \frac{m^j}{1 - T^i \alpha_D^i}[-\hat{\pi}^i - \hat{p}^i \eta^i \tau^i] + \left[\left(\frac{\alpha_D^i - \alpha_S^i}{\alpha_D^i - \alpha_S^i \theta^i}\right)\frac{m^j \tau^i}{r^i} + 1\right] r_{\theta^i}^i d\theta^i \tag{15}$$

A closer examination of (15) enables us to see that the choice of import tariff by a trading partner is conditioned upon the compensated price elasticity of import demand. More specifically, the relationship is an inverse one: the larger the price elasticity of import demand, the lower the tariff. This is seen as follows:

Let us suppose that there is an increase in the import tariff. This improves the terms of trade which means that the internal price of a country's importable good rises (i.e. there is an increase in *p*). We note that the volume of trade effect given by the second term inside square brackets is negative and increasing with η^i, thus country *i* would have to lower its best response tariff in order to counter-act the negative effect. Indeed, Syropoulos (2002a) formally demonstrates a similar result for Common External Tariffs within the context of a Customs Union.

When two trading partners are considered, we have the following relationship.

$$\left.\frac{\partial u^i}{\partial \tau^i}\right|_{\tau^i = \tau^*(\tau^j)} \overset{<}{\underset{>}{=}} 0 \text{ as } \eta^i \overset{<}{\underset{>}{=}} \eta^j \quad \forall\ i \neq j \tag{16}$$

where $\tau^*(\tau^j)$ represents the best response tariff of country i. Thus, for instance, if $\eta^1 < \eta^2$, then, by (16) $\partial u^1 / \partial \tau^1 \big|_{\tau^1 = \tau^*(\tau^2)} < 0$ which implies that country 1 would prefer its best response tariff to exceed country 2's best response tariff in order to enjoy positive welfare, hence, $\tau^1 > \tau^2$ (or, equivalently, $\tau^*(\tau^2) > \tau^*(\tau^1)$).

A closer look also reveals the following relationship between a country's marginal welfare and its expenditure share on its importable and the fraction of its GDP contributed by the import-competing sector.

$$\frac{\partial u^i}{\partial \tau^i} \stackrel{<}{\underset{>}{=}} 0 \quad \text{as} \quad \alpha_D^i \stackrel{<}{\underset{>}{=}} \alpha_S^i \theta^i \tag{17}$$

This is clear when we use (10) to obtain the following expression

$$\frac{\partial u^i}{\partial \tau^i} = \frac{e^i r^i (\alpha_D^i - \alpha_S^i \theta^i)}{[e^i (1 + \tau^i (1 - \alpha_D^i))]^2} \tag{18}$$

Given that (9) lays down the condition for imports to occur (namely, $\alpha_D^i > \alpha_S^i \theta^i$), such a relationship is not at all surprising.

Having shown that best response tariffs of trading partners can be ranked by comparing the compensated price elasticity of import demand, we can then go on to examine the dependence of this elasticity upon fundamentals. The goal of this paper is to examine the effect of technology upon tariff preferences, so the first step towards this goal is to establish an expression for the compensated elasticity of import demand in terms of the fundamental parameter of interest. Defining η^i as $\hat{m}^i / \hat{p}^i$ we find

$$\eta^i = \frac{1}{\hat{p}^i (1+\lambda^i)} \left[-\frac{\alpha_D^i \hat{\pi}^i}{1+\tau^i} + \lambda^i \left(\frac{\alpha_D^i - \alpha_S^i}{\alpha_D^i - \alpha_S^i \theta^i} \right) \frac{r_{\theta^i}^i}{r^i} d\theta^i \right] \tag{19}$$

where $\lambda^i = 1 - T^i \alpha^i_D$ (> 0)

It is notable that should $\alpha_D^i = \alpha_S^i$, the expression inside first brackets becomes indeterminate if $\theta^i = 1$; the expression also becomes indeterminate when $\theta^i = \dfrac{\alpha_D^i}{\alpha_S^i}$. In the first instance, therefore, we have to confine ourselves to cases where country *i* does not spend its entire contribution to GDP from the import competing industry on its importables. Furthermore, θ^i cannot be negative, and while it can be zero, the case where there is no contribution from technology is not interesting. This means that we are restricted to cases where $\theta^i > 0$ provided $\theta^i \neq \dfrac{\alpha_D^i}{\alpha_S^i}$. With these restrictions in mind, in our parameter space investigation, we will examine cases where $\theta^i = 1$, $0 < \theta^i < 1$ and $\theta^i > 1$.

3 Parameter Space Investigation

The shift parameter is, as we recall, an indicator of the intensity of factor usage. Changes in θ^i, therefore, can be interpreted as changes in technology. Following Dixit and Norman (1980) we specify the precise nature of the technological change by looking at three specific cases, namely product augmenting technical change, technology that results in product specific factor augmentation and general factor augmentation. For convenience, when dealing with production functions we drop country indices (superscripts now identifying commodities).

3.1 Equal Factor Proportions

Case 1: $\theta^i = 1$ (equal factor proportions), $\alpha_D^i \neq \alpha_S^i$

When $\theta^i = 1$ expression (15) becomes

$$\eta^i = \frac{1}{\hat{p}^i(1+\lambda^i)}\left[-\frac{\alpha_D^i\hat{\pi}^i}{1+\tau^i} + \lambda^i\frac{r_{\theta^i}^i}{r^i}d\theta^i\right] \tag{20}$$

expanding the numerator of the terms inside the square brackets we get $r_{\theta^i}^i d\theta^i(1+\tau^i)[1-T^i\alpha_D^i] - \alpha_D^i\hat{\pi}^i r^i$, this tells us that η^i is negative or positive depending upon whether the first term of the expansion is greater than the second term or not.

The next step is to obtain expressions for $r^i_{\theta^i}$ which we do so following Dixit and Norman.

3.1.1 Product Augmenting Technological Change

The first case we will consider pertains to technological change that solely affects the output of a specific product. In order to do this we write the production function for good i as $x^i = \theta^i f^i(v^i)$. A change in technology will therefore be equivalent to a price change. In other words, for any given factor input v^i, an increase in θ^i will yield a correspondingly higher value of production. This allows us to write the revenue function as $r^i(\theta^i p^i, v^i)$. Since we have equi-proportional changes of revenue for equi-proportional changes in prices and the shift parameter, it follows that $\theta^i(\partial r^i / \partial\theta^i) = p^i(\partial r^i / \partial p^i)$. Setting θ^i =1 and normalizing prices to unity we get $r^i_{\theta^i} = r^i_{p^i}$. In order to look at the welfare effect of product augmenting technical change we can make the appropriate substitution in (15).

For further concreteness, let us assume that only two goods are produced in the economy. Then under product augmentation, $r^i_{\theta^i} = r^i_{p^i} = x^i$. Substituting in (20) we get the following expression

$$\eta^i\Big|_{pa} = \frac{1}{\hat{p}^i(1+\lambda^i)}\left[-\frac{\alpha^i_D\hat{\pi}^i}{1+\tau^i} + \lambda^i\frac{x^i}{r^i}d\theta^i\right] \tag{21}$$

where *pa* stands for product augmenting. We now turn our attention to the next case.

3.1.2 Product Specific Factor Augmentation

In this case, we consider a technological change that has the effect of augmenting factor usage in a particular industry. For instance, there may be labor-augmenting technical progress in the production of labor intensive goods in a labor abundant economy.

For specificity, we consider a two good, two factor industry with constant returns to scale. Let the unit cost function for the production of good *i* be $c^i(w^i/\theta^i)$, where w^i represents the price of factor *i*. Since the revenue function is obtained by minimizing the value of factor endowments subject to the constraint that unit cost exceed or equal the price for all goods we have

$$r^i(p^i,\theta^i,v^i)=\min_{w^i}\{w^i v^i \,\big|\, c^i(w^i/\theta^i)\geq p^i\}$$

Let μ be the Lagrangean multiplier associated with the price constraint. Then $r^i{}_p = \mu$, and $r^i{}_\theta = \mu(w^i/\theta^{i\,2})c^i{}_1$, where $c^i{}_1$ denotes the partial derivative of c with respect to its first argument. Again, for concreteness, we use the previous result where $r^i{}_p = \mu = x^i$; we then get $r^i{}_\theta = x^i\ c^i{}_1 w^i/\theta^{i2}$, which when evaluated at $\theta^i = 1$ yields $r^i{}_\theta = x^i c^i{}_1 w^i$. Consequently,

$$\eta^i\Big|_{psfa} = \frac{1}{\hat{p}^i(1+\lambda^i)}\left[-\frac{\alpha^i_D\hat{\pi}^i}{1+\tau^i}+\lambda^i\,\frac{x^i c^i_1 w^i}{r^i}d\theta^i\right] \tag{22}$$

where *psfa* stands for product specific factor augmentation.

Comparing the two the elasticities (21) and (22) we obtain the following result:

Result 1*: If θ^i=1, $\alpha_D^i \neq \alpha_S^i$ and (19) is negative, then $\eta^i\big|_{psfa} < \eta^i\big|_{pa}$, consequently, by (16) the best response tariff associated with product specific factor augmenting technology, τ_{psfa}, is higher than the best response tariff associated with technology that is merely product augmenting, τ_{pa}, i.e. $\tau_{psfa} > \tau_{pa}$. If (19) is positive then $\eta^i\big|_{psfa} > \eta^i\big|_{pa}$ and $\tau_{psfa} < \tau_{pa}$.*

This result follows from the inverse relationship between η^i and best response tariffs as laid down earlier.

3.1.3 General factor augmentation:

In this case technological progress augments factor endowments all round. Thus, θ simply becomes a scalar multiple of endowments in the revenue function which we now write as $r^i(p^i, \theta^i v^i)$.

Recalling (16) we can see that the conditions for country i and country j to enjoy positive gains from trade are, respectively

$$\left[\left(\frac{\alpha_D^i - \alpha_S^i}{\alpha_D^i - \alpha_S^i\theta^i}\right)\left(\frac{m^j\tau^i}{r^i}+1\right)\right] r_{\theta^i}^i d\theta^i - \frac{m^j}{1-T^i\alpha_D^i}[\hat{\pi}^i + \hat{p}^i\eta^i\tau^i] > 0$$

and

$$\left[\left(\frac{\alpha_D^i-\alpha_S^i}{\alpha_D^i-\alpha_S^i\theta^i}\right)\left(\frac{m^i\tau^j}{r^j}+1\right)\right]r_{\theta^j}^j d\theta^j-\frac{m^i}{1-T^j\alpha_D^j}[\hat{\pi}^j+\hat{p}^j\eta^j\tau^j]>0 \quad i\neq j \tag{23}$$

General factor augmentation causes an improvement in the marginal contribution of the $r_\theta\, d\theta$ term and increases the value of the first term in the above expression suggesting an unambiguous improvement in overall welfare. However, immisserizing growth cannot be ruled out unless we impose more restrictions on the parameters. It is not unreasonable to posit that changes in the θ multiple could have an effect on factor and product prices, however, according to the formulation above θ does not affect these directly.

Returning to the revenue function, if v^i is normalized to 1 and, as before, we set the initial values of θ^i equal to 1 as well, we get $r_{\theta^i}^i = r_{v^i}^i$. In the 2 good case, we have already seen that $r_{\theta^i}^i = x^i$. It then follows that substitution of this result in (19) will yield identical results to that of (20), which leads to the following:

Result 2*: When there is general factor augmenting technology, the compensated price elasticity of import demand is the same as that which prevails under product augmenting technology. Consequently, the associated best response tariffs will also be the same i.e.* $\tau_{psfa}>\tau_{pa}$ *if (19) is negative and* $\tau_{psfa}<\tau_{pa}$ *if (19) is positive.*

General factor augmentation makes more factors available, thus it is possible to employ greater quantities of factors in the productive process. If that is indeed the case, then it should not be surprising that the results are indistinguishable from the product augmenting case – greater usage of any particular factor in the production of specific goods would certainly boost output. As an example, we might consider that product augmentation is simply the result of more labor being employed in a labor intensive industry. General factor augmentation would also make more labor available with exactly the same results.

3.2 Unequal Factor Proportions

Case 2: $0 < \theta^i < 1$, $\left(\theta^i \neq \dfrac{\alpha_D^i}{\alpha_S^i}\right)$

When $0 < \theta^i < 1$, then $\alpha_D^i - \alpha_S^i\theta^i > \alpha_D^i - \alpha_S^i$ but the sign of $\left(\dfrac{\alpha_D^i - \alpha_S^i}{\alpha_D^i - \alpha_S^i\theta^i}\right)$ cannot be determined with certainty. Let this quantity be denoted by φ^i. Also, let the value of θ^i that satisfies the conditions laid out above be denoted by $\tilde{\theta}^i$. First of all we have

$$\eta^i = \frac{1}{\hat{p}^i(1+\lambda^i)}\left[-\frac{\alpha_D^i\hat{\pi}^i}{1+\tau^i} + \lambda^i\varphi^i\frac{r_{\theta^i}^i}{r^i}d\theta^i\right] \tag{24}$$

As before, expanding the numerator inside the brackets gives us the expression $\varphi^i r^i_{\theta^i} d\theta^i (1+\tau^i)[1-T^i\alpha^i_D]-\alpha^i_D\hat{\pi}^i r^i$ which tells us that (24) could be positive or negative depending upon the sign and relative values of the terms.

3.2.1 Product Augmenting Technological Change

Analogous to 3.1.1 the production function for good i is $x^i = \theta^i f^i(v^i)$. A change in technology is equivalent to a price change which means for any given factor input v^i, an increase in θ^i will yield a correspondingly higher value of production. We can then write the revenue function as $r^i(\theta^i p^i, v^i)$. Again, with equi-proportional changes of revenue for equi-proportional changes in prices and the shift parameter, it follows that $\theta^i(\partial r^i/\partial\theta^i) = p^i(\partial r^i/\partial p^i)$. Setting $\theta^i = \tilde{\theta}^i$ we get $r^i_{\theta^i} = \left(\frac{p^i}{\tilde{\theta}^i}\right) r^i_{p^i}$. Now, $r^i_{p^i} = x^i$ (by duality) so that $r^i_{\theta^i} = \left(\frac{p^i}{\tilde{\theta}^i}\right) x^i$. Substituting this expression in (24) and normalizing prices to unity we get the following expression

$$\eta^i\Big|^{\tilde{\theta}}_{pa} = \frac{1}{\hat{p}^i(1+\lambda^i)}\left[-\frac{\alpha^i_D\hat{\pi}^i}{1+\tau^i} + \lambda^i\varphi^i\frac{x^i}{\tilde{\theta}^i r^i} d\theta^i\right] \tag{25}$$

We make use of this expression in the analysis that follows.

3.2.2 Product Specific Factor Augmentation

Again, for specificity, we consider a two good, two factor industry with constant returns to scale. The unit cost function for the production of good i is $c^i(w^i/\theta^i)$, where w^i represents the price of factor i. The revenue function is obtained by minimizing the value of factor endowments subject to the constraint that unit cost exceed or equal the price for all goods

$$r^i(p^i,\theta^i,v^i) = \min_{w^i}\{w^i v^i \,|\, c^i(w^i/\theta^i) \geq p^i\}$$

μ is the Lagrangean multiplier associated with the price constraint. Then $r^i_p = \mu$, and $r^i_\theta = \mu(w^i/\theta^{i\,2})c^i_1$, where c^i_1 denotes the partial derivative of c with respect to its first argument. Optimization and duality yields $r^i_p = \mu = x^i$, also $r^i_\theta = x^i\ c^i_1 w^i/\theta^{i2}$, which when evaluated at $\tilde{\theta}^i$ yields $r^i_{\theta^i} = x^i\left(\dfrac{w^i}{\tilde{\theta}^{i\,2}}\right)c^i_1$. Consequently,

$$\eta^i\Big|^{\tilde{\theta}}_{psfa} = \frac{1}{\hat{p}^i(1+\lambda^i)}\left[-\frac{\alpha^i_D\hat{\pi}^i}{1+\tau^i} + \lambda^i\varphi^i\,\frac{x^i c^i_1 w^i}{\tilde{\theta}^{i\,2} r^i}\,d\theta^i\right] \tag{26}$$

Comparing the two the elasticities we obtain the following result:

Result 3: *When* $0 < \theta^i < 1$ *and* $\theta^i \neq \dfrac{\alpha_D^i}{\alpha_S^i}$, *then* $\eta^i\Big|_{psfa}^{\tilde{\theta}} < \eta^i\Big|_{pa}^{\tilde{\theta}}$ *if (24) is negative which means that* $\tau_{psfa} > \tau_{pa}$. *The opposite holds true when (24) is positive i.e.* $\eta^i\Big|_{psfa}^{\tilde{\theta}} > \eta^i\Big|_{pa}^{\tilde{\theta}}$ *and* $\tau_{psfa} < \tau_{pa}$.

It is to be noted that this result is similar to result 1 in that if the compensated price elasticity of import demand under product specific factor augmenting technology (psfa) is lower than corresponding elasticity under product augmenting technology (pa), the associated tariff under psfa will be greater than the associated tariff under pa.

3.2.3 General Factor Augmentation:

As we recall, in this case technological progress augments factor endowments all round and θ simply becomes a scalar multiple of endowments in the revenue function which we now write as $r^i(p^i, \theta^i v^i)$. Since a one percent change in θ^i has the same effect as a one percent change in v^i we can write $\theta^i(\partial r^i / \partial \theta^i) = v^i(\partial r^i / \partial v^i)$

If v^i and prices are normalized to 1 and, as before, we set the value of θ^i equal to $\tilde{\theta}^i$, we get $\tilde{\theta}^i r_{\theta^i}^i = r_{v^i}^i$. In the 2 good case, we have already seen that $\tilde{\theta}^i r_{\theta^i}^i = x^i$. It then follows that substitution of this result in (24) will yield identical results to that of (25), which leads to the following:

***Result 4**: When $0 < \theta^i < 1$ and $\theta^i \neq \frac{\alpha_D^i}{\alpha_S^i}$, if there is general factor augmenting technology, the compensated price elasticity of import demand is the same as that which prevails under product augmenting technology. Consequently, the associated best response tariffs will also be the same.*

Result 4 is similar to result 2 in that $\tau_{psfa} > \tau_{pa} = \tau_{gfa}$ if (24) is negative and vice-versa.

3.3 Unequal Factor Proportions, $\theta^i > 1$

Case 3: $\theta^i > 1$, $\left(\theta^i \neq \frac{\alpha_D^i}{\alpha_S^i}\right)$

When $\theta^i > 1$, then $\alpha_D^i - \alpha_S^i > \alpha_D^i - \alpha_S^i \theta^i$, and the sign of $\left(\frac{\alpha_D^i - \alpha_S^i}{\alpha_D^i - \alpha_S^i \theta^i}\right)$ is indeterminate. As before let this quantity be denoted by φ^i and

$$\eta^i = \frac{1}{\hat{p}^i(1+\lambda^i)}\left[-\frac{\alpha_D^i \hat{\pi}^i}{1+\tau^i} + \lambda^i \varphi^i \frac{r_{\theta^i}^i}{r^i} d\theta^i\right] \tag{23}$$

Expansion of the numerator terms contained inside the brackets gives us the familiar expression $\varphi^i r_{\theta^i}^i d\theta^i (1+\tau^i)[1 - T^i \alpha_D^i] - \alpha_D^i \hat{\pi}^i r^i$ which tells us that (23) can be either negative or positive, furthermore, let $\breve{\theta}^i$ denote the value of $\theta^i > 1$.

3.3.1 Comparison of Product Augmenting and Product Specific Factor Augmenting Technology

In processes analogous to 3.2.1 and 3.2.2 we can obtain the following expressions

$$\eta^i\Big|_{pa}^{\breve{\theta}} = \frac{1}{\hat{p}^i(1+\lambda^i)}\left[-\frac{\alpha_D^i\hat{\pi}^i}{1+\tau^i} + \lambda^i\varphi^i\frac{x^i}{\breve{\theta}^i r^i}d\theta^i\right] \tag{27}$$

$$\eta^i\Big|_{psfa}^{\breve{\theta}} = \frac{1}{\hat{p}^i(1+\lambda^i)}\left[-\frac{\alpha_D^i\hat{\pi}^i}{1+\tau^i} + \lambda^i\varphi^i\frac{x^i c_1^i w^i}{\breve{\theta}^{i2} r^i}d\theta^i\right] \tag{28}$$

Inspection of the two elasticities shows that they differ only in the arguments of the second term inside square brackets. Without knowing precisely the values of w, c and θ it is not possible to ascertain the relative magnitude of the two elasticities with complete un-ambiguity. Given that $\theta^i > 1$, it is tempting to conclude that the second term inside parenthesis of (28) is smaller than its counterpart in (27), this is by no means certain as we do not know the relative contribution of w and c. By extension, we also cannot draw any certain conclusions regarding the effect upon external tariffs under a regime of general factor augmentation.

Result 5: When $\theta^i > 1$, $\left(\theta^i \neq \frac{\alpha_D^i}{\alpha_S^i}\right)$, *no clear conclusions can be drawn about external tariffs under different technological regimes.*

The following table provides a concise summary of the results obtained so far

Table – 1

External Tariffs under Different Parameterizations of θ and

Different Technological Regimes

Elasticity	θ^i	Tariff Ranking
$\eta^i < 0$	$0 < \theta^i \leq 1$	$\tau_{psfa} > \tau_{pa} = \tau_{gfa}$
$\eta^i > 0$	$0 < \theta^i \leq 1$	$\tau_{psfa} > \tau_{pa} = \tau_{gfa}$
$\eta^i < 0$	$\theta^i > 1$	Uncertain
$\eta^i > 0$	$\theta^i > 1$	Uncertain

psfa = product specific factor augmentation $(\alpha_D^i \neq \alpha_S^i;\ \theta^i \neq \alpha_D^i / \alpha_S^i)$
pa = product augmenting
gfa = general factor augmentation

4 Empirical Investigation

This section explores the existence of empirical evidence for the key question posited, namely, is there a link between technology and tariffs? Prior literature examining this specific point is almost non-existent. There does exist, however (within the broader category of empirical research into the determinants of trade), a strand of literature which considers technology differences between countries as an explanatory variable that drives trade. Martin and Velazquez (2002) find that the larger a country's endowment of technological capital in relation to that of its trade partners, the higher the export/import ratio of its bilateral trade. Claro's (2003) paper has already been mentioned. In it he looks at the evolution of tariffs since the mid 1980's across developed and developing countries and finds that while overall tariffs have fallen significantly, they have shifted towards protecting more capital-intensive sectors, with the bias being stronger in low wage countries. Incidentally, this paper is the only one where technology has been explicitly considered as a factor affecting the formation of tariffs.

A potential difficulty arises in obtaining a precise measure of "technology". We recall that in the theoretical part of this paper, technology was described by a shift parameter θ which was interpreted as a factor intensity parameter. Such an interpretation, in fact, helps us in establishing a meaningful measure of technology. Kakkar (2002) has shown, within the context of the Balassa – Samuelson model and using a sample of 14 OECD countries, that the capital – labor ratio in both the traded and non-traded goods sectors is co-integrated with total factor productivity (TFP), the implication being that the former can serve as an appropriate proxy of the latter. It is not unreasonable to conclude therefore that a country with a high capital to labor ratio and thus having a high TFP is possessive of a higher "level" of technology. In fact the use of the capital-labor ratio as a proxy for technology abounds in the literature. It is used by both Claro and Martin et al for example. Caselli and Coleman (2003) take a step further and define technology as a particular realization of the vector of efficiencies associated with unskilled labor, skilled labor and capital. Martin and Velazquez (2002) also chose GDP per capita as an instrumental variable for technological capital. The literature thus allows us to consider various 'measures' of technology. We consider the following – the capital-labor ratio, the ratio of skilled to unskilled labor, GDP per capita, Total Factor Productivity (TFP), the wage ratio of skilled to unskilled labor and the interest rate (i.e. the price of capital).

These measures of technology can then be regressed against average tariff rates of different countries. To avoid the biases associated with average tariff rates (i.e. the simple mean of tariffs) we use weighted average tariff rates with the weights being the share of total imports of a particular industry. The tariff rates used are from the World Bank and reported in the “Index of Economic Freedom” published by the Heritage Foundation (and can be found on the website www.heritage.org). The capital-labor ratio data are taken from Caselli and Coleman (2000) from where the ratio of skilled to unskilled labor was also computed, the Total Factor Productivity numbers are from Islam (1995). Complete data was only available for a cross-section sample of 42 countries.

In order to control for possible endogeneity we also carried out a two stage least squares (2SLS) instrumental variable regression after conducting Hausman – Wu tests. In order to be a good instrument the variable chosen for this regression should have the desirable property of being correlated with the regressor it substitutes and not with the residuals. The regressor that we felt would best comply with both requirements is the distance to the equator. In other words technology would be less ‘pervasive’ in countries that are closer to the equator, but the distance from the equator will have no bearing on the variables chosen as proxies for technology. The use of this particular regressor as an instrumental variable can be seen in Habodaszova (2003)[8]. We obtained the distances from Latitude co-ordinates published by the CIA in their World Factbook available online at www.cia.gov.

[8] In Habodaszova (2003) the distance to equator was an instrumental variable indicating the degree of corruption. I would like to thank Professor Michael Alexeev for suggesting use of this instrument in this case.

Table 2 shows descriptive statistics for the data set used in this analysis. Table 3 shows the matrix of correlation coefficients of the variables.

Table – 2

Descriptive Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum	Number of Observations
Tariff	6.84	5.80	0	28.2	42
Per Capita GDP	14,898	10,068	1,998	35,439	42
Capital Labor Ratio	36,030	30,398	2,748	107,870	42
Ratio of Skilled to Unskilled Labor	3.30	6.35	0.312	38.17	42
Wage Ratio of Skilled to Unskilled Labor	1.53	0.35	1.10	3.16	42
Interest Rate	15.15	11.62	1.97	57.62	42
Total Factor Productivity	12.37	8.25	2	38.5	42
Distance to Equator	2807.14	1,908.31	111.11	6,888.89	42

Table – 3

Matrix of Correlation Coefficients

	Tariff	Per Capita GDP	Capital Labor Ratio	Ratio of Skilled to Unskilled Labor	Wage Ratio of Skilled to Unskilled Labor	Interest Rate	Total Factor Productivity	Distance To Equator
Tariff	1							
Per Capita GDP	-0.628	1						
Capital Labor Ratio	-0.591	0.964	1					
Ratio of Skilled to Unskilled Labor	-0.308	0.577	0.518	1				
Wage Ratio of Skilled to Unskilled Labor	0.221	-0.462	-0.419	-0.160	1			
Interest Rate	0.413	-0.470	-0.482	-0.276	0.301	1		
Total Factor productivity	-0.630	0.831	0.717	0.503	-0.371	-0.493	1	
Distance to Equator	-0.457	0.742	0.722	0.389	-0.383	-0.390	0.514	1

Table 4 shows ordinary least squares (OLS) estimates of bivariate regressions with tariffs as the dependant variable.

Table 4

Bivariate Regressions: OLS, Dependant Variable – Tariffs

(*t* – statistic in parenthesis)

Independent Variable	Coefficient	Constant	R^2
Capital Labor Ratio	-0.00011* (-4.64)	10.90* (9.55)	0.349
Ratio of Skilled to Unskilled Labor	-0.281* (-2.048)	7.767* (7.975)	0.095
Per Capita GDP	-0.00036* (-5.12)	12.23* (9.64)	0.395
Total Factor Productivity	-0.443* (5.133)	12.32* (9.64)	0.397
Wage Ratio of Skilled to Unskilled Labor	3.661* (1.431)	1.244* (0.310)	0.049
Interest Rate	-0.443* (-5.133)	12.316* (9.636)	0.397

*Significant at the 5% level (critical $t = 2.01954$)

The coefficients of all the independent variables except the Wage Ratio of Skilled to Unskilled Labor are negative and significant at the 5% level. All the independent variables bar one have the expected signs. If these variables are interpreted as measuring the "level" of technology, then the country with a "higher level" of technology should have a lower corresponding average tariff rate, thus the negative relationship between average tariffs and the various measures of technology is apparent from the results shown above. However, the fit of the model does not exceed 50% for any of the measures.

The following table shows the OLS estimates when a dummy variable indicating OECD status (=1 if OECD, 0 otherwise) is incorporated.

Table – 5

OLS Regression with Dummy Variables, Dependant Variable – Tariffs

(*t* – statistic in parenthesis)

Independent Variable	Coefficient	Dummy	Constant	Adjusted R^2
Capital Labor Ratio	-0.000007 (-1.734)	-3.144 (-1.179)	10.500* (8.855)	0.372
Ratio of Skilled to Unskilled Labor	-0.068 (-0.512)	-6.519* (-3.679)	9.236* (9.836)	0.294
Per Capita GDP	-0.0003* (-2.358)	-2.295 (-0.931)	11.708* (8.426)	0.378
Total Factor Productivity	-0.319* (-3.192)	-3.800* (-2.200)	12.048* (9.820)	0.436
Wage Ratio of Skilled to Unskilled Labor	0.016 (0.007)	-6.910* (-3.981)	9.118* (2.306)	0.289
Interest Rate	0.079 (1.041)	-5.904* (-3.185)	7.605* (4.383)	0.308

*Significant at the 5% level (critical t = 2.01954)

The results with the inclusion of the dummy variables show that while the coefficients of four of the six measures are negative only the coefficients of Total Factor Productivity and its associated dummy variable are statistically significant. Also the corresponding adjusted *R* squared is the greatest of all six. This fact, in addition to the results reported in table 4 suggests that Total Factor Productivity might be the best indicator of the level of technology in a country.

A Hausman – Wu test to check for possible endogeneity in the explanatory variables was conducted with the chosen instrument being the distance to the equator. The results indicated that three out of the six variables exhibited endogeneity and we performed corresponding Two Stage Least Squares (2SLS) Instrumental Variables (IV) regressions with the results reported below.

Table – 6

2SLS IV Regressions, Dependant Variable – Tariffs

(*t* – statistic in parenthesis)

Independent Variable	Coefficient	Constant
Ratio of Skilled to Unskilled Labor	-1.072* (-2.300)	10.379* (5.422)
Wage Ratio of Skilled to Unskilled Labor	19.792* (2.149)	-23.405 (-1.657)
Interest Rate	0.585* (2.496)	-2.030 (-0.548)

*Significant at the 5% level (critical *t* = 2.01954)

R squared are not reported, as we have departed from OLS it is no longer bound in [0,1].

We note that while all the coefficients are statistically significant at the 5% level only one, the Ratio of Skilled to Unskilled Labor has a negative sign.

The principle conclusion that can be drawn from this section is that an inverse relationship exists between weighted tariff rates and certain measures of technology such as the Capital – Labor Ratio, Total Factor Productivity and the Ratio of Skilled to Unskilled Labor with the latter two standing out as more suitable because of statistical significance and consistent expected signs.

It would be interesting to repeat this empirical exercise with a richer panel data set, especially one that would allow us to carry out time series analysis and look at ‘within’ and ‘between’ effects. Inclusion of more countries and a more refined computation of the weighted average tariff rate would also be desirable. However, the principal objective of the exercise was to confirm our expectation that technology and tariffs are negatively related. In this respect we feel we have succeeded.

5. Concluding Remarks

This paper is a first attempt to examine whether technology has a bearing on the selection of tariffs by two trading partners. We have adapted the dual, general equilibrium techniques set forth by Dixit and Norman (1980) and used by Syropoulos (2002) in his examination of tariff preferences within the context of customs unions. We have seen that it is indeed possible to establish a functional dependency between technology and tariff formation. Our procedure involved first establishing the case that import tariffs could be ranked based on comparisons of the compensated price elasticity of import demand, and then obtaining closed-form expressions of that elasticity containing a technological shift variable. Interpreted as a factor intensity parameter, we then calibrated the shift variable under three separate specifications and attempted to rank best response tariffs by ranking the elasticities. We found that tariffs in the case of product specific factor augmenting technology are higher than the corresponding tariffs under a regime of specific product augmenting technology. We noted that when technology is characterized as being generally factor augmenting, tariffs mirror the product augmenting case.

Obviously a lot remains to be done. A more detailed empirical exercise has already been mentioned. Several extensions readily suggest themselves. It would be interesting to see whether inter country or inter sectoral differences in technology motivate trading partners to form preferential trading arrangements or otherwise. More precise specifications of technology could be formulated and incorporated in the model during the set up stage, though this is unlikely to ease the analytical tractability mentioned in the introduction. An interesting exercise might be to examine the feasibility of constructing a dynamic model whereby it would be possible to see the evolution of tariff formation as technology itself evolves. These and the study of various other asymmetries that affect trade and the global economy is left as the agenda for future research.

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The Impact of Country Size on the Negotiation of Sustainable Tariffs

Abstract

This paper examines reciprocal trade liberalization in a two country setting that allows for asymmetry in country size. The analysis proceeds along the lines of Furusawa (1999) wherein it is suggested that as long as status-quo tariffs are invariant during the negotiation process, the country with the higher status-quo tariff rate benefits more from the negotiation and vice-versa. We formalize this insight by explicitly introducing country size and asymmetric status-quo tariffs in a Rubinstein-type bargaining model. Our findings indicate that a large country will gain more from tariff negotiations regardless of the patience exhibited by the smaller country during the bargaining process.

1 Introduction

For several decades now, countries have engaged in mutual trade liberalization. Tariff and non-tariff barriers have been lowered either through bilateral negotiations or through multilateral agreements such as those engendered by the numerous rounds of the General Agreement on Tariffs and Trade (GATT). A feature of international trade disputes is that some are settled quickly, whereas others last much longer. In addition, some disputes are resolved due to a unilateral concession by one side while others involve reciprocal concessions. Table 1 gleaned from Bac and Raff (1997) and other sources shows several trade conflicts beginning from early mercantile history up to the present. Inspection of the table shows that in a good number of cases the larger country enjoys the benefit of a favorable settlement. This is true of cases 3, 4,5,6,7,9,19, 20 and 22. In most cases where the trading partners are of roughly equal size, notably those involving the USA and Europe (EEC or EU), either a compromise has been reached (12,13,17) or the trade disputes have lingered on (15, 21,24). Country size effects in trade disputes therefore seem to be a pertinent issue deserving of further exploration.

Furusawa (1999) points out that bilateral tariff setting usually involves a prisoner’s dilemma problem. An individual country is always better off setting a positive optimum tariff (Johnson, 1953-54) regardless of the level of the other countries tariff. However, if both countries set an optimum tariff, both are worse off. Consequently the need for cooperation in order to extract the full gains from trade exists.

Despite the need for cooperation, external enforcement of such is not possible. International institutions such as the World Trade Organization (WTO) can arbitrate trade disputes, but cannot force countries to maintain low, cooperative tariff levels. Cooperation, thus, has to be self enforcing. As Johnson (1953-54) suggests, the fear of triggering a trade war acts an incentive to engage in free trade.

A large body of literature examining this point exists. The problem has been formally addressed by embedding it in a finitely repeated game (Jensen and Thursby, 1990) and an infinitely repeated game (Dixit, 1987). Such formulations, however, fail to shed any light on the exact level of cooperative tariffs that should be selected. Bagwell and Staiger (1990, 1997a, 1997b) use a pair of most-cooperative, symmetric tariffs as the solution of symmetric games in similar contexts. The intuitive appeal of symmetric tariffs is greatly diminished, however, if countries do not share similar characteristics.

In practice, explicit mutual negotiations form the basis of most trade liberalization. Thus, the appropriate way to analyze tariff formation among countries is to model a game in which the countries negotiate over tariff rates, and then enter a phase in which the negotiated agreements are implemented and sustained in a self-enforcing manner. Bac and Raff (1997) adopt this strategy in modeling tariff-setting games.

Furusawa (1999) has shown that patience affects trade negotiation results between two countries. Specifically, the more patient country gains most from the negotiation. The analysis is simplified by the assumption that the countries are symmetric in all respects except for the discount rates. Furusawa (1999) very plausibly suggests that as long as countries do not change tariffs during the negotiation process, the country with the bigger (smaller) status-quo tariff rate benefits more (less) from negotiation thus:

> "……Provided that the countries are not allowed to change the tariffs during the negotiation, however, it is easy to see that the difference in the status quo tariffs affect the negotiation outcome in such a way that the country that has the higher (lower) status quo tariff rate benefits more (less) from the negotiation than predicted in the main analysis of the paper……"

We formalize this insight by explicitly introducing country size and asymmetric status-quo tariffs within the overall framework of Furusawa's model.

Table 1

A Summary of Trade Conflicts

Year	Countries Involved	Length of Conflict	Settlement	Nature of Conflict/Sector
1614-1617	United Provinces of Holland vs. England	3 Years	England Concedes Unilaterally	Cockayne Project: England bans export of unfinished cloth to Holland
1876, 1892	France vs. Germany		Germany Protests but does not pursue	French export subsidies on iron
1886-1893	Romania vs. Austria-Hungary	7 years	Romania concedes unilaterally	Tariff war
1886-1898	France vs. Italy	12 years	Italy concedes unilaterally	Tariff war
1892-1895	France vs. Switzerland	3 Years	Switzerland concedes unilaterally	Tariff war
1893-1894	Russia vs. Germany	1 Year	Russia concedes unilaterally	Tariff war
1894-1899	Germany vs. Spain	5 Years	Compromise, advantage Germany	Tariff war
1903-1910	Canada vs. Germany	7 Years	Germany concedes unilaterally	Tariff war over Germany's MFN status

Table -1 contd.

1922	USA vs. 29 Countries		Unilateral concession by 29 countries between 1922 and 1934	Fordney-McCumber tariff
1930-1947	USA vs. Japan, Italy, France, Spain, Britain etc.	17 Years	Settlement with Britain (1938); Geneva Round of GATT (1947)	Smoot-Hawley tariff wars
1932-1938	Britain vs. Ireland	6 Years	Anglo-Irish agreement	Tariff war
1933-1934	Britain vs. France	1 Year	Anglo-French trade agreement	Trade war
1962-1963	EEC vs. USA	1 Year	GATT mediation	Chicken war
1969-1984 (approx.)	EEC vs. USA	15 Years	Market sharing cartel	Steel war
1974	EEC vs. USA	Indeterminate		Turkey war
1975	EEC vs. USA	< 1 Year	EEC reduces export subsidies	Cheese war
1982-present	Canada vs. USA		Indeterminate	Softwood Lumber
1985-1986	EEC vs. USA	1 Year	Compromise	Pasta war
1985-1986	EEC vs. USA		EEC concedes	Grain dispute
1986	USA vs. South Korea		South Korea concedes unilaterally	TV programs, motion pictures
1986	USA vs. Taiwan		Taiwan concedes unilaterally	Tariff calculations
1999- 2003	USA vs. Japan	4 Years	WTO rules against Japan	Steel war
2002-present	USA vs. EU		Indeterminate	Steel war
2003-present	USA vs. EU		Indeterminate	GM agricultural products dispute

Sources: Bac and Raff (1987), British Broadcasting Corporation, US State Department, Government of British Columbia, Canada

2 Theoretical Background

2.1 Nash's Bargaining Theory

In this section we provide the underlying theoretical foundation of the analysis which follows. It is based upon Nash's general approach to bargaining theory with the notation and exposition drawn mainly from Binmore (1987). The approach employed is strictly "game theoretic" i.e. only optimal play between rational players with individual goals is considered. "Behavioral" theories (theories which seek to describe individual behavior in practice) or "ethical" theories (theories which prescribe outcomes that are desirable from the viewpoint of society as a whole) are ignored for the purposes of our analysis.

According to Nash (Binmore and Dasgupta, 1987) the most fundamental type of game is a contest – a formal two-person game in extensive form which is analyzed under the assumption that no pre-play communication is allowed. For contests, the most commonly used solution concept is the Nash equilibrium. However, for games other than contests, the possibility of pre-play interaction between players can have important bearings on the final outcomes. In a bargaining game, for example, if one player is able to make a pre-emptive offer, he enjoys a first mover advantage. The other player is then left with a "take it or leave it" position. The roles could be reversed, or simultaneous moves can be made, in which case the outcomes would be different.

The problem of pre-play interaction is dealt by Nash (1951) along the following lines –

Let *G* denote a formal game. Let *N* denote a larger "negotiation game" wherein various possible steps in the pre-play negotiation procedure are played out and the negotiation procedure is formalized. A strategy for the formal game *N* tells us how to conduct the negotiations under all possible eventualities and how to choose a (possibly) mixed strategy for *G* contingent upon the course the negotiations took. The solution of the negotiation game, analyzed as a contest, leads to an outcome of the game *G* which is termed the "negotiated" outcome of *G*.

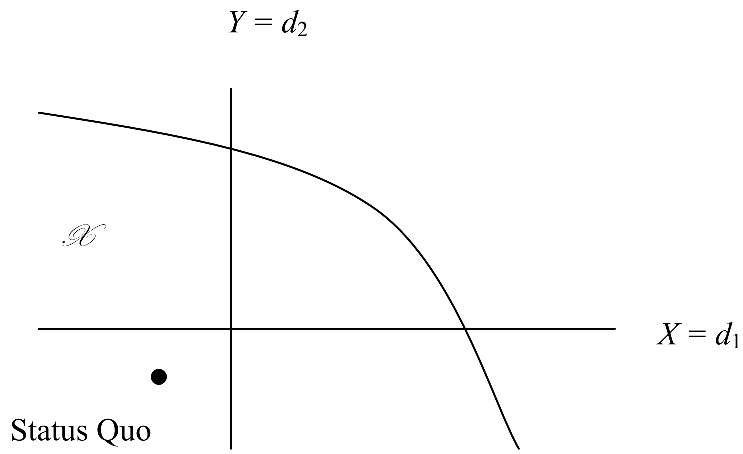
A "bargaining contest" *B* associated with a game *G* is a negotiation contest in which any pair of negotiation strategies (one for each player) can be classified as either compatible or incompatible. If compatible, the choice of these negotiation strategies results in a pre-determined outcome of *G* which is called the "status quo".

In order to illustrate this point Binmore (1987) offers a simple example. He considers a standard Edgeworth market exchange in which two countries engage in a trade game. The first player has a quantity *X* of some commodity and the second player has quantity *Y* of some other commodity. This is transformed into a formal game *G* by stipulating that the strategies for the two players consist of the unilateral transmission of some proportion of their initial endowment to the other. Assuming that each player has a utility function defined over the set of relevant commodity bundles and that this is commonly known, an opportunity for barter now exists. Binmore and Dasgupta (1987) take the view, following Nash, that the results of the barter will depend on the nature of the strategies open to the players. In the absence of binding agreements, the “negotiated” outcome of *G* will be the initial endowment point. Interesting negotiation outcomes will therefore emanate only from binding agreements. However, the nature of the negotiated outcomes will depend on the negotiating procedure and what the players regard as constituting the solution of the resulting negotiation contest.

Nash considered a simple bargaining procedure in which each player simultaneously announces a real number. The announcements of the real numbers by the players represent a demand for an outcome of *G* which yield the players utility equivalent to their announcements. A pair of announcements is compatible if a pair of (possibly mixed) strategies for *G* exist whose implementation leads to each player receiving the utility demanded. Such compatibility results in a binding agreement to implement the strategy pair. Incompatibility of the demands results in status-quo. In this case that is the initial endowment (or “no-trade”) point.

The original game *G* preceded by the bargaining procedure described above constitutes a bargaining contest *B* which has many Pareto-efficient Nash equilibria. Indeed, every Pareto-efficient outcome of *G* can be realized as the result of a Nash equilibrium of *B* under suitable concavity assumptions on the utility functions. Under such assumptions, with free disposal, the set $\mathscr{X}$ of achievable utility pairs is illustrated in the following figure

Figure – 1



Under these circumstances, the demands d_1 and d_2 together constitute a Nash equilibrium B if and only if (d_1, d_2) is a Pareto efficient point of $\mathscr{X}$.

For the theory to hold, the players must recognize one of these Nash equilibria as the solution of the game. For this purpose the players require a "convention". Such a convention may be observed through repeated plays of the game as long as;

1. The players all subscribe to a common game theory.
2. The games are played separately (i.e. the players do not treat the games as sub-games of a larger super-game).

Provided the players observe a common convention, the bargaining contest *B* can be solved. This solution then determines the negotiated outcome of the original game G. In our particular example, the negotiated outcome consists of a contract to exchange specific quantities of X and Y.

Now, the formal play of game G can be preceded by any number of bargaining procedures. At the same time there are also numerous conventions which might be used in the solution of the bargaining contests. Nash was of the view that despite the varied nature of the bargaining solutions, they all shared a common strategic structure and would thus lead to similar negotiated outcomes. In support of this view, Nash (1950) formulated a system of axioms for the negotiated outcome of a game G with given status quo. On the basis of his axioms, Nash was able to show that only *one* negotiated outcome (in terms of utilities) is possible. This is the "Nash bargaining solution". We provide a brief account of Nash's system of axioms following Binmore (1987) in the following section.

2.2 Nash's System of Axioms (Binmore 1987)

There is a set of formal two-person games G in extensive form with each terminal node labeled with an element ω from an outcome space $\Omega = \Omega(G)$. The lottery λ in which the prize ω_j is obtained with probability p_j is denoted by

$$\lambda = \begin{Bmatrix} \omega_1 & \omega_2 & \dots & \omega_k \\ p_1 & p_2 & \dots & p_4 \end{Bmatrix}$$

The set of all such lotteries with prizes in Ω is denoted by $L = L\ (\Omega)$. Each player has a preference relation defined on L which is described by a von Neumann –

Morgenstern utility function defined on *Ω*. The linear extensions of these utility functions to *L* are denoted by $\phi_1 \mapsto \mathbf{R}^2$ and $\phi_2 \mapsto \mathbf{R}^2$. $\phi \mapsto \mathbf{R}^2$ is defined by

$$\phi(\lambda) = (\phi_1(\lambda), \phi_2(\lambda))$$

The payoff region $X = X(G)$ for the game G is

$$X = \phi(L)$$

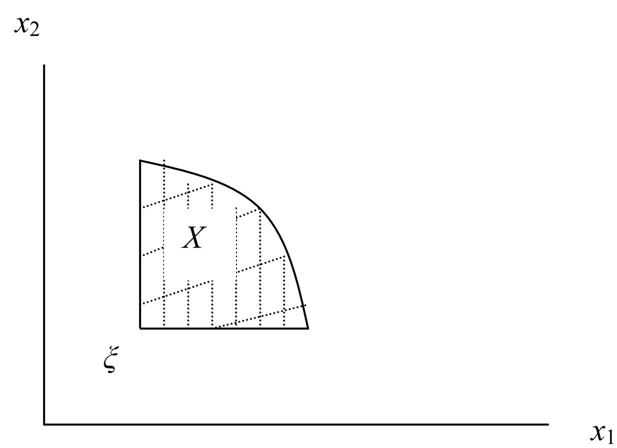
where the set X is a convex subset of $\mathbf{R}^2$ and X is also assumed to be compact.

The play of the game *G* is preceded by a period of bargaining. One of a set of formal bargaining procedures are used, embedding *G* a greater bargaining contest *B*. A pair of bargaining strategies (one strategy for each player) are either compatible or incompatible. If incompatible, their play results in a pre-specified outcome *q* of *L* called the status quo which is denoted as

$$\xi = \phi(q)$$

and depicted in the following diagram

Figure – 2



We note further that

$$
\begin{aligned}
&i.\ \ X \subseteq \{\mathbf{x} : \mathbf{x} \geq \xi)\\
&ii.\ \ X \bigcap \{\mathbf{x} : \mathbf{x} > \xi\} \neq \phi\\
&iii.\ \ (\xi < \mathbf{x} \leq \mathbf{y} \text{ and } \mathbf{y} \in X) \Rightarrow \mathbf{x} \in X
\end{aligned}
$$

The set of all pairs (X, ξ) with these properties is denoted by D.

The set of axioms Nash gave for his bargaining solution is a list of restrictions on the function $f : D \rightarrow \mathbf{R}^2$. Nash showed that his axioms specify a unique function $f : D \rightarrow \mathbf{R}^2$. The axioms, which are mathematical properties of the function f are

Axiom 1 (feasibility)

$$\xi < f(X, \xi) \in X$$

Axiom 2 (invariance)

For any strictly increasing, affine transformation $\alpha : \mathbf{R}^2 \rightarrow \mathbf{R}^2$,

$$f(\alpha X, \alpha\xi) = \alpha\, f(X, \xi)$$

Axiom 3(efficiency)

$$\mathbf{y} > f(X,\xi) \Rightarrow \mathbf{y} \notin X$$

Axiom 4 (independence of irrelevant alternatives)

$$f(X,\xi) \in Y \subseteq X \Rightarrow f(Y,\xi) = f(X,\xi)$$

Axiom 5 (symmetry)

$$\begin{gathered} \textit{If} \quad \tau : (x_1, x_2) \mapsto (x_2, x_1), \text{ then} \\ f\ (\tau X, \tau\xi) = \tau\, f\,(X,\xi) \end{gathered}$$

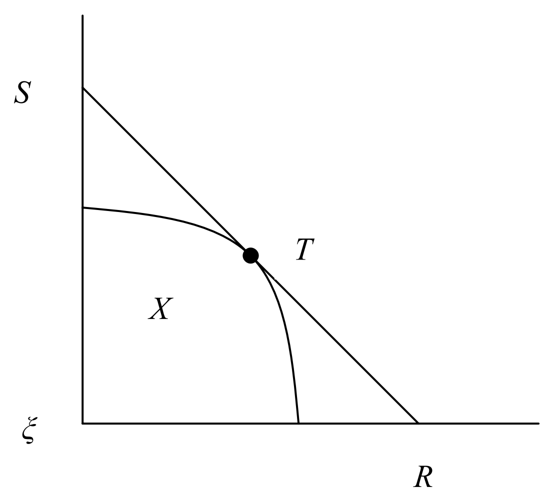
Nash shows that, with these assumptions, $f(X,\xi)$ is the point $x \in \mathbf{R}^2$ at which

$$\underbrace{\max}_{\substack{x \in X \\ x > \xi}} (x_1 - \xi_1)(x_2 - \xi_2)$$

is achieved. The axioms determine f uniquely. The uniquely determined function $f(X, \xi)$ is called the 'Nash bargaining solution' of the game G.

A diagrammatic exposition illustrates things more clearly. Given τ ($0<\tau<1$), we can define $g_\tau(X, \xi) = T$, where T is the point indicated in figure 3.

Figure – 3



RS is a supporting line to the convex set X and T is chosen so that $ST/SR = \tau$. An alternative way of defining T is the point where

$$\underbrace{\max}_{\substack{x\in X\\ x>\xi}} (x_1 - \xi_1)^\tau (x_2 - \xi_2)^{1-\tau}$$

is achieved. Now g_τ is referred to as the "asymmetric Nash bargaining solution' of G and τ and $\tau - 1$ are the associated "bargaining powers". It is to be noted that g_τ satisfies axiom 5 iff $\tau = 1/2$.

While the asymmetric Nash Bargaining solution forms the cornerstone of our analysis, an important aspect of the bargaining game B ought to be noted. We recall that B is a separable bargaining contest which separates into n Nash demand games $B_1, B_2, \ldots, B_n$, if that is indeed the case the question naturally arises as to which Nash equilibria, played separately in $B_1, B_2, \ldots, B_n$, yield a Pareto-efficient outcome for B? The answer to this question is that the pairs of demands made in $B_1, B_2, \ldots, B_n$ must all be asymmetric Nash bargaining solutions for the n separate games, all of which correspond to the same value of τ. The necessity of a convention to arrive at a bargaining solution has already been explained within the context of repeated plays of the game. However, if only a single game is considered, any convention that is adopted will necessarily appear to be arbitrary. Consequently, there is a need for a bargaining contest in which a solution can be identified without appealing to any convention. By applying further structure to the Nash demand game Binmore (1987) comes up with a couple of "modified" Nash demand games where the distortion imposed by the additional structure is sufficiently small to yield results that are approximately equal to the Nash bargaining solution. One of these games is adopted by Furusawa in his analysis of tariff negotiations. We elaborate below.

2.3 A Modified Nash Demand Game

In the simple Nash demand game the players were required to make simultaneous demands and the set of feasible payoffs was perfectly known. This is not a particularly realistic situation. Binmore (1987, pp 65 – 70) has analyzed a game where the second requirement was relaxed; however, for our purposes we are interested in the game where the first assumption is relaxed and the players make sequential moves.

It is assumed that at time $t = 0$ the first player makes a demand (or offer) which is either accepted or rejected by the second player. Acceptance leads to the termination of negotiations with the first player receiving his demand and the second player receiving the maximum utility consistent with the first player's payoff. Rejection of the first player's demand leads to a continuation of negotiations with the second player making a demand (or counter-offer) after some time interval T which the first player can either accept or reject, so on and so forth.

It is further supposed that the players react negatively to the delay of an agreement. This is modeled by assuming that the set of feasible payoffs at time t is

$$X_t = \{\delta_1^t x, \delta_2^t y) : (x, y) \in X\}$$

where $0<\delta_1<1$ and $0<\delta_2<1$. Players are allowed to have possibly different discount rates δ_1 and δ_2. In the event that no demand (or offer) is ever accepted both players receive zero. The status-quo is therefore zero.

Using results from Rubinstein (1982) who describes the set of perfect equilibrium outcomes for a class of games embodying the structure described above and who shows that there is a *unique* perfect equilibrium outcome, Binmore shows that the solution is an approximation of the asymmetric Nash bargaining solution with bargaining power τ where

$$\tau = \frac{\log \delta_2}{\log \delta_1 + \log \delta_2}$$

Provided the time interval T is sufficiently small ($T \rightarrow 0$). We note that $\delta_1 = \delta_2$ leads to the symmetric Nash bargaining solution where $\tau = 1/2$. Furthermore $T \rightarrow 0$ approximates the case where demands (or offers) are made simultaneously.

2.4 Application of Nash's Bargaining Theory to Strategic Tariff Games.

The analytical framework established above is especially suitable for the analysis of strategic tariff games. Dixit (1987), in particular, provides a very illuminating early exposition of the use of strategic game theory in the study of trade policy. In particular he notes that it makes good sense to conduct trade policy analysis within the broader framework of non-cooperative game theory and points out several pertinent reasons why:

- Trans-national enforcement mechanisms for multi-lateral or bilateral co-operative arrangements are weak at best.
- The laws of contract and tort are usually absent or inapplicable in an international setting.
- National sovereignty often affords foreign governments immunity from legal sanction.
- Supra-national protocols established under the GATT or the WTO are bypassed or even flouted.

Given these points, it is wise to adopt a framework in which the players act independently and any co-operation that emerges is tacit and sustained by the players' self-interest. Factors which sustain this interest may include the possibility of the arrangement collapsing or prospective 'punishment' meted out by the other country, but not steps taken by any external trans-national body.

As has been mentioned in the introduction, Furusawa (1999) makes use of Nash and Binmore's results in his analysis. In the next section we describe it in some detail as we feel it is central to the analysis which follows.

3 Country Size and Tariff Negotiations

In this section we provide an exposition of Furusawa's model of tariff negotiations when the two countries involved are of equal size. This analysis is later extended to incorporate size asymmetries.

Furusawa's basic model is a two phase game played by the governments of two countries which are assumed to be equal in size. Each imposes a common optimum tariff on its imports. This tariff, τ^N, prevails until the countries agree upon a new pair of tariffs via negotiation with τ_i for $i = 1, 2$ denoting the rate of the specific tariff country i imposes on its imports. Each government tries to maximize the social welfare of its own country. Government i for $i = 1, 2$ discounts the future at rate r_i. It is assumed that government 1 is more patient than government 2 i.e. $r_1 < r_2$.

In the first (negotiation) phase of the game, the governments alternate in offering a pair of tariff rates (τ_1, τ_2), until an offer is accepted by the other government in the manner of Rubinstein (1982). To eliminate the first mover advantage in Rubinstein's bargaining model, Furusawa considers a limit situation in which the time lag of successive offers approaches zero. This formulation preserves the effect of patience on the bargaining outcome since the difference in patience does not vanish even in the limit.

The implementation phase begins as soon as the two governments agree on a new pair of tariff rates which replace the status quo tariffs. During this phase the governments continue to set the tariffs at the agreed upon levels until a government defects by selecting some other tariff rate. The defection is discovered and punished after a time lag of Δ. It is assumed that both governments adopt a trigger strategy in which they would revert back to τ^N once punishment starts. The implementation phase is considered to be an infinitely repeated game in discrete time of period length Δ, and a mutually beneficial, cooperative outcome is supported by a subgame perfect equilibrium. The discount factor of government i is given by $\delta_i = e^{-r_i\Delta}$; furthermore, we have $\delta_1 > \delta_2$ from the assumption $r_1 < r_2$, and δ_i falls as Δ increases. Furusawa notes that the effect of difference in patience on bargaining power during trade negotiations is twofold – on the one hand patience pays off in the negotiation phase as it enhances bargaining power, however, impatience pays during the implementation phase since the resulting greater incentive to defect enables governments to claim a larger share of the fruits of cooperation. When the two countries are of equal size, the former effect outweighs the latter if the time lag between defection and punishment in the implementation phase is short, and vice-versa.

Furusawa defines the stage game payoff for government i as $\int_0^{\Delta} e^{-r_i t} W(\tau_i, \tau_{-i}) dt$, where $W(\bullet)$ denotes the instantaneous social welfare function calculated as the sum of the total surpluses from the importable and exportable goods markets, and is equal to $[(1 - \delta_i)/r_i]W(\tau_i, \tau_{-i})$. Using a partial equilibrium framework, Furusawa derives explicit expressions for $M(\tau)$ and $X(\tau)$, the sum of which is $W(\bullet)$. The unique stage Nash equilibrium tariff, τ^N, is calculated to be 1/3[1]. The symmetry assumption allows the use of the same function $W(\bullet)$ for each country. Figure 4 illustrates the world market for good i and the resulting $M(\tau_i) + X(\tau_{-i})$ reaches a maximum at $\tau = 0$. This implies that the two countries joint payoff is maximized at free trade when $\tau_i = \tau_{-i} = 0$.

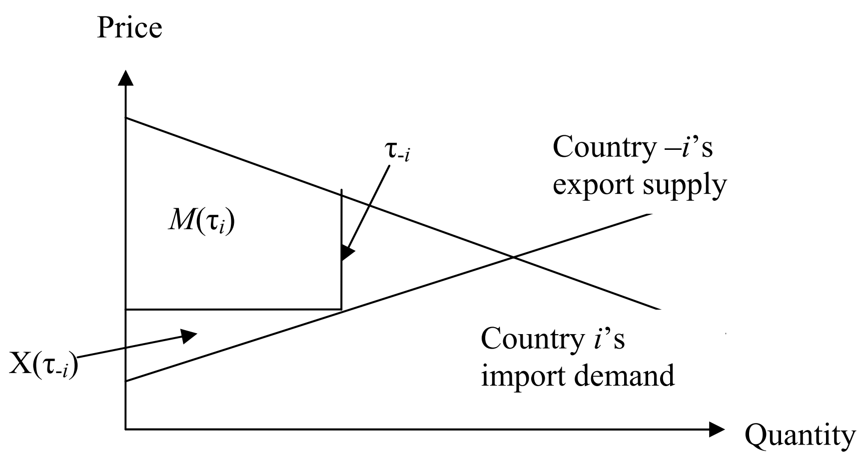


Figure – 4: Surpluses from imports and exports of good i

[1] The function M is derived as follows: Consider the world market for good i , and let p_x and τ denote the price of that good in the exporting country and tariff rate of the importing country respectively. The world market clearing condition $(1- p_x) + (1- p_x - \tau) = 1$ implies $p_x = (1 - \tau)/2$ which gives us the price for the importing country and quantity of imports as $(1 + \tau)/2$ and $(1 - \tau)/2$ respectively. The instantaneous total surplus in the importable-good market is the sum of consumer and producer surplus $M(\tau) = (1/2)(1 - (1+\tau)/2)((1- \tau)/2) + \tau ((1 - \tau)/2) = (1 - \tau)(1 + 3\tau)/8$, the FOC $M'(\tau) = 1/3$ gives us the Nash equilibrium tariff of the stage game.

In order to examine size effects we require tariffs to be expressed in terms of fundamental endowment parameters. In fact, doing so will allow us to study the effects not only of size, but also of dissimilar status quo tariff rates. Kennan and Riezman (1988) present a model of tariff wars where Nash equilibrium tariffs are indeed expressed in terms of endowments. We use the results of Kennan and Riezman in Furusawa's basic model to analyze the effects on tariff negotiation of the aforementioned asymmetries.

Kennan and Riezman (1988) use a model with two countries *A* and *B*, and two goods *X* and *Y*. Each country contains many consumers with identical quasi-linear utility functions $U^A = X^A Y^A$, and $U^B = X^B Y^B$. The world endowment of each commodity is defined to be one unit. Country *A* has γ units of *X* and *B* has $1 - \gamma$ units; country *B* has μ units of *Y* and *A* has $1 - \mu$ units. Using this basic framework, Kennan and Riezman (1988) show that the Nash equilibrium tariffs for countries *A* and *B* as functions of the endowments are $\left[\dfrac{\gamma}{1-\mu}\right]^{1/2}$ and $\left[\dfrac{\mu}{1-\gamma}\right]^{1/2}$ respectively (please see the appendix for an explicit derivation). These tariffs will correspond to τ_1 and τ_2 in our model where they will take the place of τ^N, the optimum stage Nash equilibrium tariff.

We begin by mirroring the analysis of Furusawa. His baseline model, in which the countries are of equal size, is simply the case where $\tau_1 = \tau_2 = \tau^N$, which we use as our starting point. In figure 5, R_1 and R_2 represent the reaction curves for countries 1 and 2 respectively, and the interaction of the curves shows the Nash equilibrium of the stage game. Two representative indifference curves corresponding to $W(\tau_1,\tau_2)$ and $W(0,0)$ are also drawn. The closer an indifference curve is to the axis of its own tariff rate, the higher the corresponding welfare.

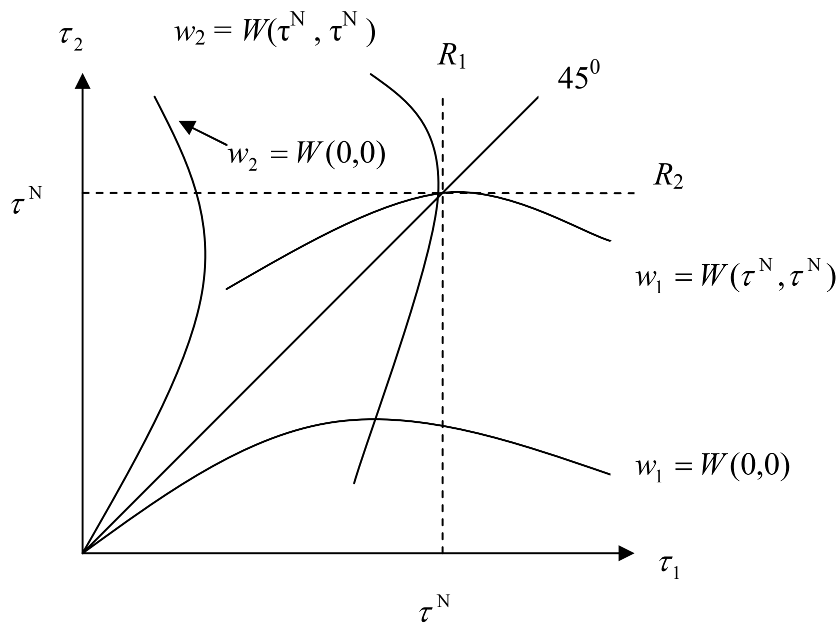


Figure – 5: The stage game

3.1 Negotiated Pairs of Sustainable Tariffs

The fundamental premise of Furusawa's model is that any pair of negotiated tariffs chosen for implementation must be self-enforcing. Each government i continues to set a cooperative tariff rate τ_i for as long as neither government has deviated from this pair in the past. Defection by at least one government will result in both governments setting their own tariff rates at τ^N in the next period and every period thereafter. This trigger strategy profile constitutes a known subgame perfect equilibrium, and the set of all such pairs of sustainable tariff rates is referred to as the implementable set.

The average discounted sum of government *i*'s stage game payoff is

$$(1-\delta_i)\sum_{t=0}^{\infty}\delta_i^t\left(\frac{1-\delta_i}{r_i}\right)W(\tau_i(t),\tau_{-i}(t)) \tag{1}$$

where $\tau_i(t)$ and $\tau_{-i}(t)$ denote the tariff rates of country *i* and –*i* (any number not *i*) in period *t*. Since government *i* would derive the maximum benefit from deviation when it sets the tariff rate at τ^{N}, we can express the incentive constraint for government *i* as follows

$$\left(\frac{1-\delta_i}{r_i}\right)W(\tau_i,\tau_{-i}) \geq (1-\delta_i)\left(\frac{1-\delta_i}{r_i}\right)W(\tau^{\mathrm{N}},\tau_{-i})+\delta_i\left(\frac{1-\delta_i}{r_i}\right)W(\tau^{\mathrm{N}},\tau^{\mathrm{N}}) \tag{2}$$

The left hand side shows the average discounted payoff when both governments cooperate while the right hand side shows the average discounted payoff when only government *i* deviates. After the common term is dropped we have

$$W(\tau_i,\tau_{-i}) \geq (1-\delta_i)\,W(\tau^{\mathrm{N}},\tau_{-i})+\delta_i\,W(\tau^{\mathrm{N}},\tau^{\mathrm{N}}) \tag{3}$$

We recall that the instantaneous social welfare of country *i* calculated as the sum of the total surpluses from the import and export goods markets is W:[0,1) × [0,1) → **R** and is defined by

$$W(\tau_i, \tau_{-i}) = M(\tau_i) + X(\tau_{-i}) \tag{4}$$

The functions $M(\tau)$ and $X(\tau)$ are shown by Furusawa to be concave and convex, respectively.

Using (4) the incentive constraint (IC_i) is simplified as

$$M(\tau^{N}) - M(\tau_i) \leq \delta_i \left\{X(\tau_{-i}) - X(\tau^{N})\right\} \tag{5}$$

for i = 1, 2. A pair of tariffs (τ_1, τ_2) is in the implementable set if and only if IC_1 and IC_2 are simultaneously satisfied and $\tau_1, \tau_2 \geq 0$. Figure 6 shows the incentive constraints for the two governments with the shaded area as the implementable set.

The implementable set is the area which is surrounded by the two incentive constraints and the two axes of the (τ_1, τ_2) plane. The incentive constraints will shift out with an increase in δ_i as the more patient government i is more willing to cooperate in tariff setting. Importantly, in this case, the implementable set is asymmetric in favor of the relatively impatient country 2 (recall: $\delta_1 > \delta_2$).

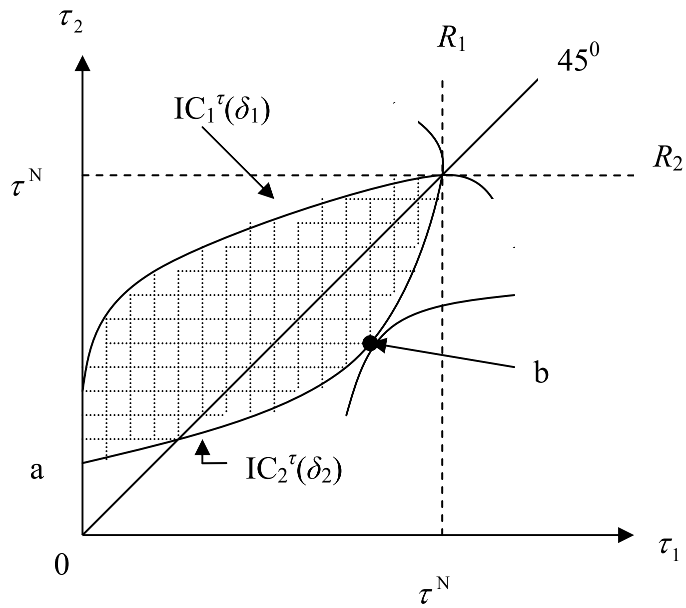


Figure 6: The implementable set

The implementable set can be transformed into the space of instantaneous social welfare which allows us to find the feasible set of negotiation. Figure 7 shows an example of the feasible set that corresponds to the implementable set shown in figure 6.

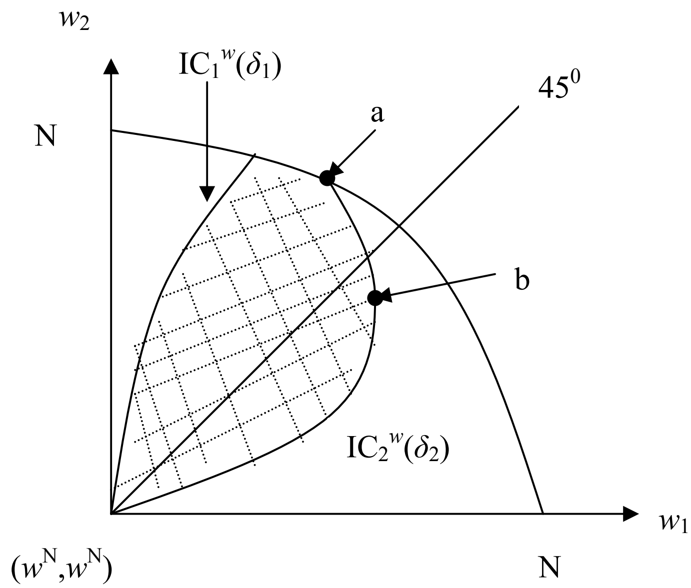


Figure – 7: The feasible set

In figure 7, $\mathrm{IC}_i{}^{w}(\delta_i)$ is the locus in the payoff space as a pair of tariffs moves along $\mathrm{IC}_i{}^{\tau}(\delta_i)$ in figure 5. For any given δ_i , $\mathrm{IC}_i{}^{w}(\delta_i)$ is backward bending due to the convexities of $\mathrm{IC}_i{}^{\tau}(\delta_i)$ and each indifference curve of country $-i$. For instance, the backward bending portion *ab* of $\mathrm{IC}_2{}^{w}(\delta_2)$ corresponds to the segment *ab* in figure 2. As δ_i increases, $\mathrm{IC}_i{}^{\tau}(\delta_i)$ in figure 5 shifts out, which decreases τ_i on $\mathrm{IC}_i{}^{\tau}(\delta_i)$ for any given τ_{-i}. Thus $\mathrm{IC}_1{}^{w}(\delta_1)$ shifts up and $\mathrm{IC}_2{}^{w}(\delta_2)$ shifts to the right as δ_1 and δ_2 increase, respectively. The NN curve is the locus in the payoff space as a pair of tariffs moves along the axes in figure 5. The feasible set is the area surrounded by $\mathrm{IC}_1{}^{w}(\delta_1)$, $\mathrm{IC}_2{}^{w}(\delta_2)$ and the NN curve. It is tilted in favor of country 2 since $\delta_1 > \delta_2$ and expands as either δ_1 or δ_2 increases.

From the feasible set the governments select a pair of tariff rates through negotiation. The solution concept adopted by Furusawa is the limit of the subgame perfect equilibrium of the Rubinstein bargaining model as the lag between offers converges to zero. Binmore (1987) shows this to be equivalent to the asymmetric Nash bargaining solution. Denoting the feasible set as $X \subset \mathbf{R}^2$ and representing a disagreement point by $(\xi_1, \xi_2) \in X$, the asymmetric Nash bargaining solution is given by argmax $\{(x_1 - \xi_1)^{\theta} (x_2 - \xi_2)^{1-\theta}\}$, with $\theta = r_2 / (r_1 + r_2)$ being the discount rate of player i which can be treated as being player i's "bargaining power". Binmore (1987) suggests that the disagreement point in the Nash bargaining problem should be the status quo payoffs when the problem is interpreted as a limit problem of the Rubinstein bargaining model. This follows from the fact that in the Rubinstein model, a disagreement is made up of an infinite repetition of offers and rejections so that the status quo payoffs last forever. Applying Binmore's result, Furusawa finds that the solution is characterized by the tangency between the Pareto-frontier and a level curve of the asymmetric Nash product $(w_1 - w^{\mathrm{N}})^{\theta} (w_2 - w^{\mathrm{N}})^{1-\theta}$, where $w^{\mathrm{N}} = W(\tau^{\mathrm{N}}, \tau^{\mathrm{N}})$.

For any given r_1 and r_2, the Pareto frontier consists of the NN curve and the backward bending portions of the incentive constraints if Δ is small enough. As Δ increases, both the incentive constraints shift in, which then makes the Pareto frontier consist only of the backward bending portions of $\mathrm{IC}_i^{w}(\delta_i)$. If Δ is as high as $e^{-r_2} \equiv \delta_2 < \underline{\delta}$, the Pareto frontier lies entirely above the 45^0 line.

Which country benefits more from the negotiation depends on the size of Δ. If Δ is very small, a large part of the Pareto frontier consists of the middle portion of the NN curve which Furusawa shows to be concave to the origin and symmetric with respect to the 45^0 line. This, combined with the fact that the slope of the level curve at any point (w_1, w_2), of the asymmetric Nash product $(w_1 - w^N)^\theta (w_2 - w^N)^{1-\theta}$, is steeper than that of the symmetric Nash product $(w_1 - w^N)(w_2 - w^N)$ means that the solution lies in the lower portion of the NN curve. Thus the negotiation outcome favors country 1 more than country 2. If, on the other hand, Δ is very large, the Pareto frontier lies entirely above the 45^0 line. Consequently the negotiation outcome favors country 2 more than country 1. So for $\tau_1 = \tau_2 = \tau^N$, we have the following proposition.

Proposition 1 (Furusawa, 1999): *For any r_1 and r_2, there exists a critical response lag $\Delta^*(r_1, r_2)$ such that the two countries equally benefit from the negotiation, i.e. $w_1 = w_2$, if the response lag equals $\Delta^*(r_1, r_2)$; country 1 benefits more than country 2, i.e., $w_1 > w_2$, if $\Delta < \Delta^*(r_1, r_2)$; and country 2 benefits more than country 1, i.e., $w_1 < w_2$, if $\Delta > \Delta^*(r_1, r_2)$.*

Proof: Please see Furusawa (1999).

3.2 Asymmetrical Tariffs and Country Size

This baseline result using equal status quo tariff rates follows from the assumption that the 2 countries are of equal size. Relaxing the original assumption of equal size but retaining the assumption that government 1 is more patient (i.e. $r_1 < r_2$) leads to the following possibilities:

A. Government 1 is more patient than government 2 and country 1 is bigger than country 2.

B. Government 1 is more patient than government 2 but country 2 is bigger than country 1.

The first possibility is described by the set of conditions $r_1 < r_2$ and $\left[\frac{\gamma}{1-\mu}\right]^{1/2} > \left[\frac{\mu}{1-\gamma}\right]^{1/2}$, while the second possibility by $\left[\frac{\gamma}{1-\mu}\right]^{1/2} < \left[\frac{\mu}{1-\gamma}\right]^{1/2}$. We note that expressing the status quo tariffs in terms of endowments allows us to view them as corresponding to country size.[2] Thus, we can consider the cases where $\tau_1^N > \tau_2^N$ and $\tau_1^N < \tau_2^N$ such that the size of the tariff will indicate country size. This formulation allows us to assess the impact of differences in country size as well as status-quo tariffs.

It can be inferred that under possibility A, country 1 is going to benefit even more than under the baseline model since the feasible set of negotiation is going to

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[2] For example if $\gamma = 0.7$ and $\mu = 0.5$ then $[\gamma/(1-\mu)]^{1/2} > [\mu/(1-\gamma)]^{1/2}$, please see Appendix 2 for a more detailed treatment.

be asymmetrically skewed much greater in its favor. This follows from the fact that in the stage game, country 1 enjoys greater welfare from the outset. Figure 8 depicts this.

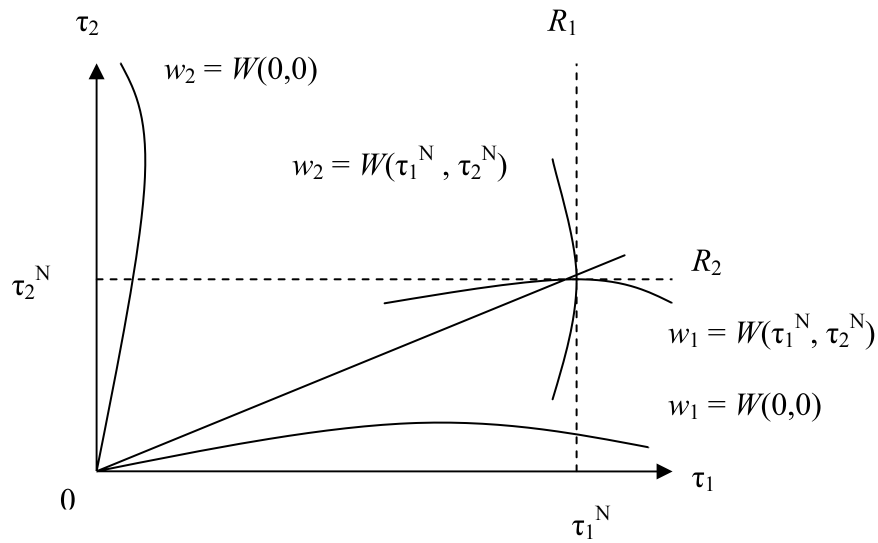

Figure 8: The stage game when $\tau_1^N > \tau_2^N$

The indifference curve depicting the welfare level of country 1 at the Nash equilibrium is much closer to the axis of its own tariff rate, indicating a much higher level of welfare. The corresponding diagram depicting the feasible set is drawn to reflect this.

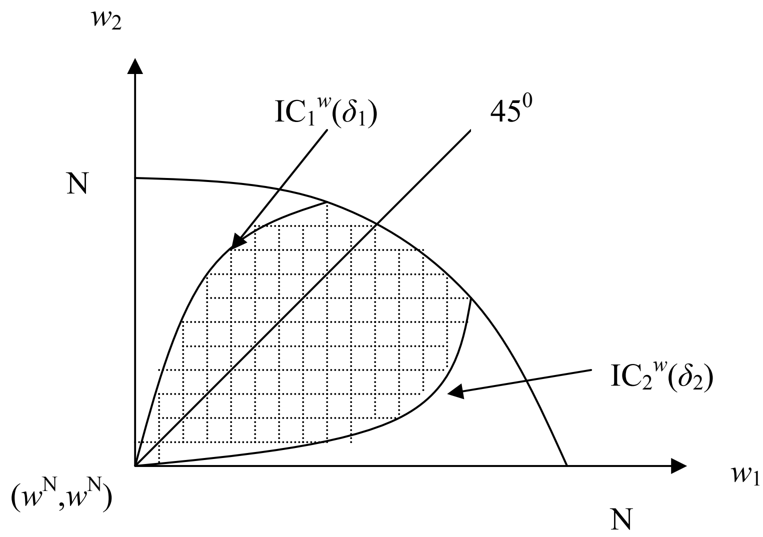

Figure – 9: The Feasible set when $\tau_1^N > \tau_2^N$

It is possible to infer from figure 9 that country 1 may benefit to a much greater extent from the negotiation process than was possible when the two countries were of equal size. First, we note that the payoff space bounded by the locus NN is skewed in country 1's favor, second, for country 2 to benefit from the negotiation, the solution, as described above, must occur to the left of the 45^0 line. For this to happen, the response lag Δ has to be sufficiently big. In contrast to the symmetrical case, however, the larger size of country 1 affords a cushion against the negative effects of greater Δ in the implementation phase since country 1 can credibly threaten to retaliate (by manipulating the terms of trade in its favor for example) should country 2, the impatient country, defect in an attempt to claim a larger share of the fruits of cooperation. On the other hand, if Δ is short, it can be expected that country 1 would benefit to a much greater extent during the negotiation phase. These observations are expressed in proposition 2.

Proposition 2*:* *If country 1 is bigger as well as more patient than country 2, it suffers less from the negotiation outcome when Δ is large and benefits to a greater extent from the negotiation outcome when Δ is small, than would have been the case had the countries been of equal size.*

Next we turn our attention to the case where government 1 is more patient than government 2 but country 2 is bigger. The NN locus in figure 10 is drawn to reflect this.

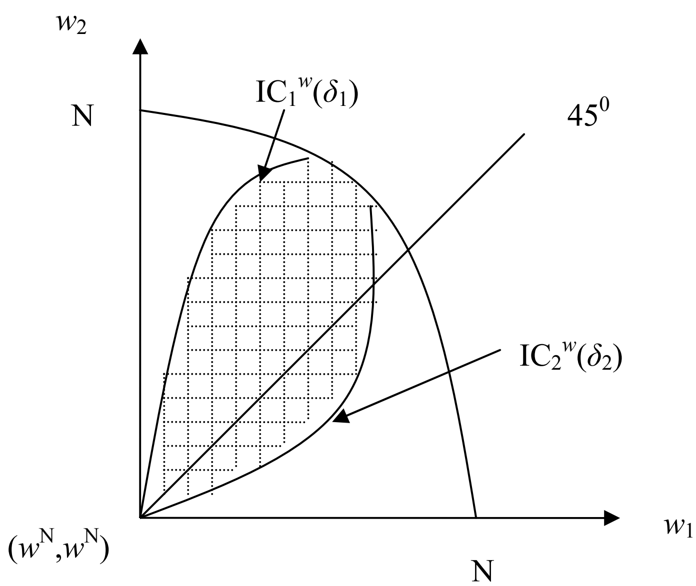

Figure –10

We recall that patience strengthens bargaining power in the sense of Rubinstein (1982), but then again, greater patience may also negatively affect the government's bargaining position through the shift in the implementable set in favor of the other country. This follows from the patient government being more willing to give its rival a relatively larger share of the fruits of tariff cooperation in order to keep the rival within the bounds of the cooperation framework during the implementation phase.

As Furusawa demonstrates, if Δ is very small in the symmetrical case, the gain from defection is insignificant, so the incentive constraint is not binding for either government at the asymmetric Nash bargaining solution. In this instance, only the first effect through explicit negotiation prevails, meaning that the negotiation outcome favors the more patient government. In the case where one country, in our case country 2, is bigger and the other country more patient (country 1) we postulate that this effect can be reversed. Country 2 can expect to gain from defection even if Δ is small since the smaller country cannot credibly retaliate (in the sense of Kennan and Riezman). In fact, in complete contrast to the symmetrical case, it is in the interest of government 1 to seek a settlement which keeps its own incentive constraint binding. This observation leads us to the following simple proposition:

Proposition 3: *Patience alone is not sufficient to overcome a disadvantage caused by smaller size.*

It is clear therefore that a tremendous advantage is afforded by country size. An advantage that cannot be negated either by means of greater patience or by means of early defection in the implementation phase. This means that a country that finds itself at a disadvantage in trade negotiations due to its smaller size must seek other ways to redress the imbalance. One way might be to “gang up’’ which might account for the formation of trading blocs consisting of smaller nations – a point which is brought into relief when we consider the bargaining strength of say the EU versus a single European country in trade negotiations with the US.

4 Concluding Remarks

By combining the results of Kennan and Riezman (1988) within the overall framework of Furusawa's basic model (1999) we examined the effect of country size on the negotiation of sustainable tariffs. We have confirmed the insight that large country size imparts a major advantage during the trade negotiation. Support for this insight can be found in the existing literature (Baier, 2001, Harrison et al., 1991, Dakhlia et al., 2004). Some extensions suggest themselves. It would be worthwhile to examine the dynamics of tariff negotiations when growth is incorporated in the model and empirical validation of the results set out in this paper are also desirable.

Appendix 1: The derivation of status quo tariffs in terms of endowments (Kennan and Riezman, 1988)

There are two countries, *A* and *B*, two goods *X* and *Y*. Each country has many consumers with identical utility functions

$$U^A = X^A Y^A \qquad U^B = X^B Y^B \tag{1}$$

where X^A, Y^A, X^B and Y^B denote consumption levels of each good in each country.

The world endowment of each commodity is one unit. Country *A* has γ units of *X* and *B* has $1 - \gamma$ units; country *B* has μ units of *Y* and A has $1 - \mu$ units. The endowments are divided equally between consumers within countries. In equilibrium, *A* exports *X* to *B* and imports *Y* from *B*. Country *A* charges a tariff at the rate $S - 1$ on imports of *Y* and *B* charges a tariff of $T - 1$ on imports of *X*. World prices are denoted by *P* and *Q*, so the domestic price of *Y* in *A* is *SQ*, and the price of *X* in *B* is *TP*.

Consumers in *A* face prices *P* and *SQ*, and maximize U^A subject to the budget constraint

$$PX^A + SQY^A = I^A = P\gamma + SQ(1-\mu) + (S-1)QY \tag{2}$$

Utility is maximized by allocating equal expenditures to each good, so that

$$\pi(\gamma - X) = \pi X^A = SY^A = S(1-\mu+Y) \tag{3}$$

where π is the world price ratio *P/Q*. When the budget constraint (2) is used to eliminate π from equation (3) the result is *A*'s offer curve:

$$\frac{\gamma}{X} = \frac{S(1-\mu)}{Y} + S + 1 \tag{4}$$

Given any tariffs *S* and *T*, *A*'s offer curve (4) and the analogous equation for *B* are linear in the reciprocals of imports and exports, so they can be solved to obtain the market clearing consumption levels. Thus

$$X^A = \gamma - X = \frac{\gamma + (1-\mu)T}{1 + (1-\mu)T + \mu / S} \tag{5}$$

$$Y^A = (1-\mu) + Y = \frac{\gamma + (1-\mu)T}{T + (1-\gamma)ST + \gamma}$$

Then *A*'s utility level is

$$U^A = X^A Y^A = \frac{[\gamma + (1-\mu)T]^2}{[1 + (1-\mu)T + \mu / S][T + (1-\gamma)ST + \gamma]} \tag{6}$$

The optimal tariff problem for *A* is to choose a tariff which maximizes the utility of the representative consumer at the market clearing levels of X^A and Y^A. From (6), the first order condition for this problem is

$$\frac{\mu}{S^2[1+(1-\mu)T+\mu/S]}=\frac{(1-\gamma)}{1+(1-\gamma)S+\gamma/T} \tag{7}$$

This can be written as a quadratic equation in *S* which (implicitly) defines *A*'s tariff reaction function. The reaction function for the two countries can be solved to obtain the Nash equilibrium tariffs as functions of the endowments:

$$T^N=\tau_1^{\mathrm{N}}=\left[\frac{\gamma}{1-\mu}\right]^{1/2} \quad , \quad S^N=\tau_2^{\mathrm{N}}=\left[\frac{\mu}{1-\gamma}\right]^{1/2} \tag{8}$$

Appendix 2: Tariff size and utilities.

Let, $\tau_1^N = \left[\frac{\gamma}{1-\mu}\right]^{1/2} = a$ and $\tau_2^N = \left[\frac{\mu}{1-\gamma}\right]^{1/2} = b$

Then, $\gamma = a^2(1-\mu)$ and $\mu = b^2(1-\gamma)$ which allows us to express μ and γ in terms of a^2 and b^2 hence,

$$\mu = \frac{b^2(1-a^2)}{1-a^2b^2} \quad \text{and} \quad \gamma = \frac{a^2(1-b^2)}{1-a^2b^2}$$

The Nash equilibrium utility level for *A* can then be found by substituting for the tariffs in equation (6) of appendix 1. This yields:

$$U_{Nash}^A = \frac{a^{1/2}(b-1)}{ab-1} \tag{8}$$

The utility level of *A* at free trade can be found by setting $S = T = 1$ in equation (6) which gives us

$$U_{Free\,Trade}^A = \frac{2a^{1/2}(1+ab)}{(1+a^2)(1+b)} \tag{9}$$

A will then gain from a tariff war if $U_{Nash}^A > U_{Free\,Trade}^A$ i.e. if

$$\frac{a^{1/2}(b-1)}{ab-1} > \frac{2a^{1/2}(1+ab)}{(1+a^2)(1+b)} \quad \text{or} \quad \frac{2a^{1/2}(1+ab)}{(1+a^2)(1+b)} > 1 \tag{10}$$

Interchanging *a* and *b* gives the condition for *B* to win a tariff war.

We can obtain a graphical expression of (10) in terms of the endowment parameters γ and μ by appropriately replacing a and b and simplifying to obtain the equivalent condition

$$\frac{2\left(\frac{\gamma}{\mu-1}\right)^{1/4}\left(1+\sqrt{\frac{\gamma}{1-\mu}}\sqrt{\frac{\mu}{1-\gamma}}\right)(\mu-1)}{(1-\mu-\gamma)\left(1+\sqrt{\frac{\mu}{1-\gamma}}\right)}>1 \tag{11}$$

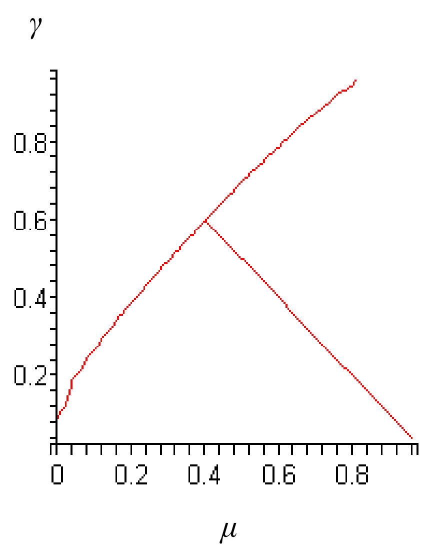

Figure 11

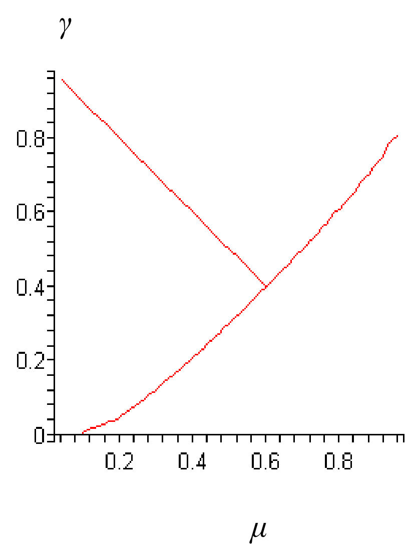

Figure 12

Figure 11 shows the implicit plot of (11). We note that at (0.4,0.6) the function is bifurcated. That is because when $\mu = 0.4$ and $\gamma = 0.6$ the Nash equilibrium tariffs of both countries are the same and equal to 1, so there is no tariff "war" as such. Thus, there is a range of values for which the inequality (10) does not *strictly* hold. A would win the tariff war if the endowments were such that (10) strictly held.

Figure 12 shows the case where B wins the tariff war (inequality (10) with a and b interchanged).

As we confine our analysis to the cases where (10) holds we can interpret this condition intuitively (as do Kennan and Riezman) by looking at the following diagram (figure 13) which is constructed by superimposing the figures 11 and 12.

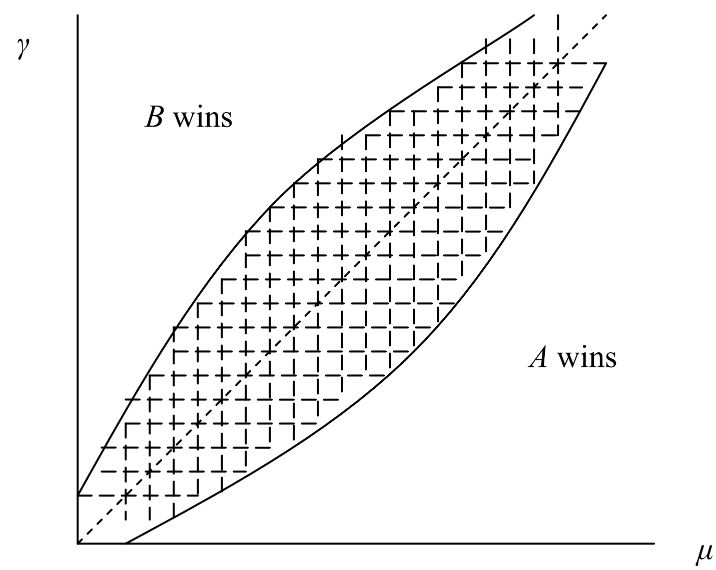

Figure 13

Any point in the southeast region of the diagram gives an endowment that will result in country A winning a tariff war while any endowment in the northeast region of the diagram will lead to country B winning the war. If the endowment vector falls within the shaded area no country wins a tariff war.

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The use of some New Measures of Outward Orientation to assess the relationship between Openness and Country Size

Abstract

Two new measures of openness, namely the Trade Restrictiveness Index and the Mercantile Trade Restrictiveness Index are used to empirically examine the relationship between a country's size and outward orientation. We find that the inverse relationship between country size and openness which is reported in the literature holds when these two measures are employed.

1 Introduction

A recent body of economic literature deals with the determinants of trade openness and identifies country size as being a pertinent variable (Ades et al., 1994; Wacziarg, 1997; Alesina et al., 1997, 1998). Specifically, the relationship between the two is an inverse one, smaller countries are more likely to be open to trade than larger ones. The intuition behind this relationship is aptly summarized by Alesina et al. (1998) who posits that in the absence of international trade markets are identified by political boundaries which results in countries facing economic incentives to be large. If, on the other hand, a country is able to trade with the rest of the world, political boundaries prove less of a constraint on market size. Consequently, as the international trade regime becomes more and more liberal, various ethnic groups or regions find it both feasible as well as less costly to separate. Since smaller countries need to trade in order to be economically viable, support for the liberal trade regime will intensify. Essentially, small countries need to trade in order to enjoy the benefits of access to a bigger market. One can therefore expect smaller nations to be more open to trade than their larger counterparts. Alesina et al. (1998) find empirical evidence to support this conjecture.

In their paper Alesina et al. (1998) use the share of imports and exports over GDP as their principle measure of openness and regress it on measures of country size and other controls.[1] Given the difficulties associated with this measure (and other traditional measures) we employ some new measures of openness recently

[1] Other measures of outward orientation such as average tariff rates were also used and the qualitative findings were reported; however the actual regression results were not.

developed by Anderson and Neary (1994, 1996, 2003; hereinafter AN) to see if the results of Alesina et al. hold. We find that our results do in fact agree with the spirit of their findings.

Section 2 is a theoretical discussion of the pitfalls of traditional measures of trade openness and a description of the new measures introduced by Anderson et al. Section 3 describes the regression results, section 4 discusses some limitations of the new measures while section 5 concludes.

2 The measurement of trade openness – traditional and new indices

The crudest measure of protection, which is sometimes computed when data is lacking, is the simple (un-weighted) average of tariff rates across different commodities. Obviously this measure is disadvantaged by the fact that it ignores the relative importance of a traded good i.e. it treats all commodities identically and is sensitive to changes in the classification of goods in the tariff schedule. A better measure would then be one that incorporates a weighting scheme for tariffs reflecting the relative importance of imported goods.

A commonly used improved measure that is employed by researchers to quantify the level of protection in an economy is the trade-weighted average tariff which uses actual trade volumes as weights.

$$\tau^w = \frac{1}{m}\sum_i m_i \tau_i \qquad (1)$$

where m_i is the import of good i, τ_i is the tariff levied on good i, and m is the level of total imports. This measure is unsatisfactory because it suffers from the classic index number problem – as the tariff on any good i is increased, the import volume of that good decreases which leads to a commensurate decline in the weight associated with the good. If tariffs are high enough, the decline in the weight may be so large that the index is decreasing in the tariff rate. In the extreme case, if tariffs are prohibitively high, the associated weights fall to zero and the tariffs no longer contribute to the index. It is also to be noted that tariffs have pronounced effects on both welfare and trade volume when they are levied upon imports that have a relatively elastic demand, yet it is exactly these goods whose weights decrease most rapidly.

A way around this problem may be to abandon the use of current import volumes altogether and instead use the import volumes that would prevail under free trade (Leamer, 1974). While this allows us to avoid the downward bias associated with the trade weighted index we are still left with the practical problem of obtaining free trade import volumes which are not directly observable.

Other measures of trade restrictiveness have been no less unsatisfactory. Some researchers (notably Alesina et al. (1998) as mentioned above) have used the ratio of total trade volume (imports plus exports) to GDP as a measure of openness. This measure is unconvincing for two reasons, first is the very plausible possibility that the equilibrium ratio of total trade to GDP may be low for a particular economy in free trade; second, within the context of its relationship to country size, the two variables may 'cause' each other (as is indeed noted by Alesina et al. (1998)). Leamer (1987) developed a measure of trade openness based on an empirical

Heckscher – Ohlin (H-O) trade model where protectionism is evidenced by non conformity to the predictions of the model. Unfortunately, the H-O model may not adequately describe the patterns of trade in the latter half of the 20th century.

Given the aforementioned problems associated with the traditionally used indices recent attempts have been made to create universal tariff measures that are grounded in economic theory rather than relying on ad-hoc weighting schemes. The seminal contributions in this regard are by Anderson and Neary (AN) with their Trade Restrictiveness Index (TRI, 1996) and Mercantilist Trade Restrictiveness Index (MTRI, 2003). We briefly discuss these measures below.

2.1 The Trade Restrictiveness Index (TRI)

The TRI is superior to the traditional indices described above in that it is based on sound analytical foundations. It is defined as the uniform tariff equivalent (UTE) which has the same static welfare effect as the existing structure of ad-valorem tariffs. If we consider the standard partial equilibrium analysis of the effects of a tariff on a small open economy (figure 1), the quota equivalent of a tariff τ is AB, in other words it is the quota that produces the same static welfare loss (as indicated by the shaded Marshallian triangles) as the tariff (O'Rourke, 1997). The TRI is simply the uniform tariff which would have exactly the same static welfare effect as the structure of tariffs and quotas actually in place. It is a weighted average tariff but instead of trade shares there are now marginal welfare weights.

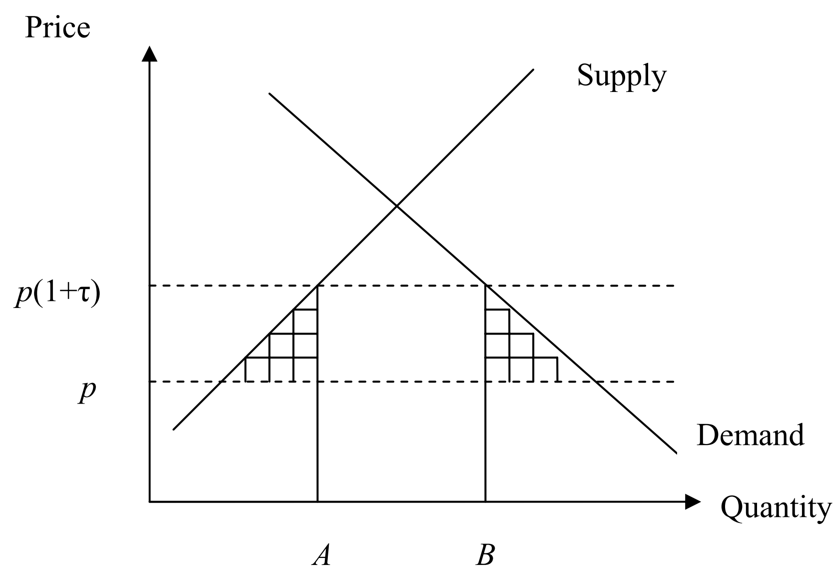


Figure 1: Effect of a Tariff on a Small Open Economy

More formally the problem is to find u such that

$$V(\tau_1, \ldots, \tau_i, \ldots) = V(u, \ldots, u, \ldots) \tag{2}$$

where $(\tau_1, \ldots, \tau_i, \ldots)$ is the system of ad-valorem tariffs and V is the representative consumer's indirect utility function. The UTE is thus a more theoretically exact tariff aggregator since it is derived from utility considerations. In practice, derivation of the index requires us to explicitly model the economy in a general equilibrium (GE) framework. A computable general equilibrium (CGE) model must be specified and calibrated using available data and various assumptions regarding preferences and technology. To shed more light on this issue we provide a brief exposition based on AN (2003).

A general model of a tariff-distorted open economy is developed by first assuming a single representative consumer, the economy in competitive equilibrium, no distortions other than tariffs and the price of traded goods being fixed in the world markets.

The trade expenditure function $E(\pi, u)$ describes private sector behavior. This represents the expenditure needed to attain utility level u facing a price vector π of traded goods subject to tariffs net of income received from ownership of the factors of production. Spending and income are represented by the expenditure and GDP functions respectively

$$E(\pi,u)=e(\pi,u)-g(\pi) \tag{3}$$

Factor endowments, prices of non-traded goods, factor prices and prices of traded goods not subject to tariffs are in the background and have been suppressed[2]. The price derivative of the trade expenditure function is the economy's general equilibrium utility-compensated (i.e. Hicksian) import demand function

$$E_{\pi}(\pi,u)=m^{c}(\pi,u) \tag{4}$$

Public and private sector behavior is summarized by the balance of trade function

[2] Factor prices and the price of non-traded goods are endogenous given π and u.

$$B(\pi,u) \equiv E(\pi,u) - (\pi - \pi^*) \cdot E_\pi(\pi,u) \tag{5}$$

where the last term on the right hand side is the inner product of tariff wedge $(\pi - \pi^*)$ between domestic and world prices (denoted by a *) and the import demand function. The expression is equivalent to tariff revenue. The economy is in equilibrium when the balance of trade constraint is satisfied. This requires that utility be at a level that equates (5) to any exogenous income b

$$B(\pi,u) = b \tag{6}$$

The balance of trade function (6) summarizes the equilibrium of an economy subject to tariffs in a single equation. This is the basis on which AN (1996) introduce the TRI as implying the uniform tariff rate τ^Δ implicitly defined as follows

$$\tau^\Delta : \; B[(1+\tau^\Delta)\pi^*, u^0] = b^0 \tag{7}$$

where u^0 and b^0 are some initial levels of utility and income respectively. The value of τ^Δ is the uniform tariff which would ensure balance of payments equilibrium at the initial level of utility. [3]

[3] Δ itself is defined as the factor of proportionality by which period 1 prices must be deflated to ensure that equilibrium prevails when utility is at its period 0 level. In AN 1996 this is equal to the inverse of one plus the uniform tariff equivalent which would yield the same level of welfare as the initial policy instruments. Since Δ is a deflator, it is a compensating variation type of measure, an increase in Δ corresponds to an increase in trade restrictiveness.

2.2 The Mercantilist TRI (MTRI)

The TRI evaluated the restrictiveness of trade policy using welfare as the benchmark. The MTRI on the other hand employs the initial import volume as the reference point.

The starting point of the MTRI is the import volume function $M(\pi, b)$ which is the volume of imports evaluated at world prices when the vector of domestic prices of the distorted traded goods is equal to π and the trade balance is equal to b

$$M(\pi, b) = \pi^* \cdot E_\pi(\pi, u) \tag{8}$$

where the level of u is compatible with balanced trade (i.e. (6)). Then the MTRI gives the uniform tariff τ^μ which yields the same volume (at world prices) of tariff restricted imports as the initial tariffs, M^0

$$\tau^\mu : M[(1+\tau^\mu)\pi^*, b^0] = M^0 \tag{9}$$

The TRI and MTRI both represent theoretically based indices. Consequently they avoid the biases associated with more traditional tariff weight based indices. They are based on optimizing behavior and are constructed within the framework of GE models of the economy. Whereas the TRI is derived from welfare considerations, the MTRI uses trade volume as its point of reference. It is worth reiterating once again that both the TRI and MTRI are indices that compare the actual tariff structure with those of free trade. AN (2003) provide a comparative theoretical discussion of the two indices.[4] They compute these two indices for a cross-country sample of 25 nations and also provide the weighted average tariff rates (Tariff) for the same sample. We utilize this data set to explore the relationship between country size and trade restrictiveness

3 Openness and Country Size

In order to assess the relationship between openness and country size, we regress a set of openness indices against country size principally measured by the log of population. To the cross-section data of *TRI* and *MTRI* for 25 countries compiled by AN we add some more measures of openness which are described fully below. We also include the log of area and log of per capita GDP as well as a series of dummy variables corresponding to a country's status as an oil exporter, geographical location or membership of the OECD. The estimated 'openness' equation is inspired by Alesina et al. (1998) and assumes the following form

$$OM = \beta_0 + \beta_1 Population + \beta_2 PerCapitaGDP + \beta_3 Area + \beta_4 D_1 + \beta_5 D_2 + \beta_6 D_3 + \beta_7 D_4 + \beta_8 D_5 + \varepsilon \quad (10)$$

[4] Among the theoretical issues discussed are the conditions under which the *MTRI* exceeds the trade weighted average tariff and the fact that the *MTRI* can *never* exceed the *TRI*.

where OM = Openness Measure, D_1 = Oil Exporter Dummy, D_2 = Africa Dummy, D_3 = South and S.E. Asia Dummy, D_4 = OECD Dummy and D_5 = Latin America Dummy. (D_1 = 1 if Oil Exporter 0 otherwise etc.)

The openness measures chosen include *TRI* and *MTRI* described above along with three others, namely the percentage of exports as a percentage of GDP (*XGDP*), import duties as a percentage of total imports (*Import*) and average weighted tariffs (*Tariff*)[5]. Due to the problems of causality mentioned on page 86 we drop the use of the ratio of total trade (exports and imports as a percentage of GDP) as a measure of openness for the present analysis. *XGDP* is essentially trade intensity measure while *Tariff* and *Import* are measures of trade restriction like the *TRI* and *MTRI*.

Table 1 lists all raw data and Table 2 shows the matrix of correlations for the various measures of openness. We see that the restriction based indicators *TRI*, *MTRI*, *Tariff* and *Import* are positively correlated. We also note that the relationship between the restriction based measures and *XGDP* is weakly correlated.

These observations are mirrored in Figure 1 where the cross-country results are plotted. One notes the especially close relationship between *MTRI* and *Tariff* (correlation coefficient of 0.98726). However, AN (2003) caution us that the two measures should not be used interchangeably for different countries because even-though Tariff under-predicts *MTRI* in 22 out of the 25 cases only slightly (8.9% on average), the under-prediction exceeds 15% for 4 countries (Austria, Indonesia, Morocco and the USA) and *Tariff* actually over-predicts *MTRI* by about 7% for India. Furthermore, the *TRI* consistently exceeds the *MTRI* which is in line with the theoretical prediction of AN in their paper.

[5] *Tariff* as an openness measure can also be found in Yannikaya (2003)

Table – 2

Correlation Matrix for the various openness indicators.

	XGDP	*Tariff*	*TRI*	*MTRI*	*Import*
XGDP	1.0000				
Tariff	-0.0843	1.0000			
TRI	0.1041	0.8626	1.0000		
MTRI	-0.0555	0.9873	0.8861	1.0000	
Import	0.2044	0.1233	0.2661	0.0590	1.0000

Since the *TRI*, *MTRI*, *Tariff* and *Import* are all trade restriction measures we can carry out tests of hypothesis of equal means. The results of such tests are shown in Table 3 below.

Table – 3

Tests for Equality of Means

Null Hypothesis	Computed *t* score	Decision ($\alpha = 0.05$)
$\mu_{TRI} = \mu_{MTRI}$	2.699	Reject Null
$\mu_{TRI} = \mu_{Import}$	3.484	Reject Null
$\mu_{TRI} = \mu_{Tariff}$	3.189	Reject Null
$\mu_{MTRI} = \mu_{Import}$	1.181	Do not reject Null
$\mu_{MTRI} = \mu_{Tariff}$	0.557	Do not reject Null
$\mu_{Import} = \mu_{Tariff}$	-0.711	Do not reject Null

Table 4 represents the regression results (*t* – ratios in parenthesis). Alesina et al. report that country size (as measured by population) and openness are negatively related when openness is measured as the ratio of total trade to GDP, our regression results mirrors this aspect; they also report that tariff rates are positively related to country size and our results also agree. In fact, it is striking to note that while the trade intensity measure *XGDP* is negatively related to country size the restrictiveness measures (*Tariff*, *TRI*, *MTRI* and *Import*) are all positively related. However, only the Logs of Population, Per Capita GDP and Area are statistically significant at the 10% level when the employed dependant variable is *XGDP*.

Table – 4
Regression Results

Dependant Variable	*XGDP*	*Tariff*	*TRI*	*MTRI*	*Import*
Constant	60.999	2.177	-3.893	-1.810	34.001
	(1.489)	(0.090)	(-0.136)	(-0.069)	(1.089)
Log Population	-4.678	0.687	1.678	0.959	1.020
	(-1.953)	(0.484)	(1.006)	(0.630)	(0.563)
Log Per Capita GDP	8.571	1.044	2.533	1.655	-2.592
	(1.911)	(0.393)	(0.811)	(0.580)	(-0.765)
Log Area	-3.826	-0.310	-1.395	-0.587	-0.844
	(-1.768)	(-0.242)	(-0.925)	(-0.427)	(-0.516)
Oil Exporter Dummy	3.809	-1.588	-0.935	-0.933	-1.744
	(0.824)	(-0.580)	(-0.290)	(-0.317)	(-0.499)
Africa Dummy	-7.625	-5.111	2.630	-3.821	7.069
	(-0.691)	(-0.782)	(0.342)	(-0.545)	(0.848)
South and S. East Asia Dummy	12.337	3.573	14.911	4.325	3.798
	(1.250)	(0.612)	(2.168)	(0.689)	(0.509)
OECD Dummy	-20.855	-6.283	-4.685	-6.409	-0.962
	(-1.847)	(-0.940)	(-0.596)	(-0.893)	(-0.113)
Latin America Dummy	-14.602	-1.058	1.495	-0.486	-1.356
	(-1.412)	(-0.173)	(0.207)	(-0.74)	(-0.173)
Adjusted R^2	0.631	0.154	0.485	0.118	0.185

In other words the larger a country, the lower is its trade intensity i.e. lower is the proportion of it’s GDP that is determined by ‘interaction’ with the outside world and the larger a country, the higher it's 'restrictiveness' to external trade. Either way, the conclusion is the same. Smaller countries are more open to trade than their larger counterparts. Our observations appear to agree with the findings of the existing theoretical and empirical literature. At the very least, the spirit of the findings of Alesina et al. (1998) seems to be robust to the definition of openness used.

4 The TRI and MTRI – Some Limitations.

The TRI and its extension the MTRI introduced in a series of papers by AN represent the most theoretically sound measures of protection (openness) available to researchers. In practice both are computed by calibrating a Computable General Equilibrium (CGE) model of the economy the details of which are omitted here. Suffice to say that AN's CGE model is tractable and robust to changes in the elasticities which are embedded in it. Nonetheless, the TRI, in particular, has received some criticism, notably by O'Rourke (1997) who argues that while the index is indeed robust to changes in elasticities it can be sensitive to changes in the specification of the underlying CGE model and provides a historical example to illustrate his point. One should thus be cognizant that in practice, the index number problem is essentially replaced by a question over the correct specification of the CGE model i.e. the appropriate elasticities of substitution in preferences and technology.

More seriously, Dakhilia and Temimi (DT, 2004) cast doubt over the existence and uniqueness of the TRI when countries involved are large[8]. We recall that the TRI (and MTRI) is an index that compares the actual tariff structure with that in free trade (section 2), in other words, the TRI is calculated on the basis of self inflicted losses that come about as a result of deviation from the free trade ideal. Herein lies the problem. DT (2004) argue that for large countries the optimal tariff may be non-zero. While tariffs do restrict trade, they may not necessarily be detrimental to the welfare of a large country especially if it has a big economy where other forms of taxes such as sales taxes are either impractical or ineffective and tariffs represent the best option for raising revenue. Furthermore, a positive level of tariffs can improve the terms of trade and, of course, there may exist lobbying groups representing special interests. These being the case, DT contend that for a large country, the appropriate benchmark to measure the cost of protectionism is deviation from the welfare-maximizing tariff structure and not the vector of zero tariffs.

They suggest an extension of the TRI to large economies, namely the Uniform Tariff Deviation Equivalent (UTDE), an index which continues to maintain the essence of the TRI in that it is a measure of protection which is a function of the welfare cost relative to a welfare optimum, where the optimum is no longer free trade but a welfare-maximizing tariff vector.

In light of the limitations described above, the use of the TRI as a measure of protection and the interpretation of any analytical or empirical results obtained thereof has to be conducted with caution.

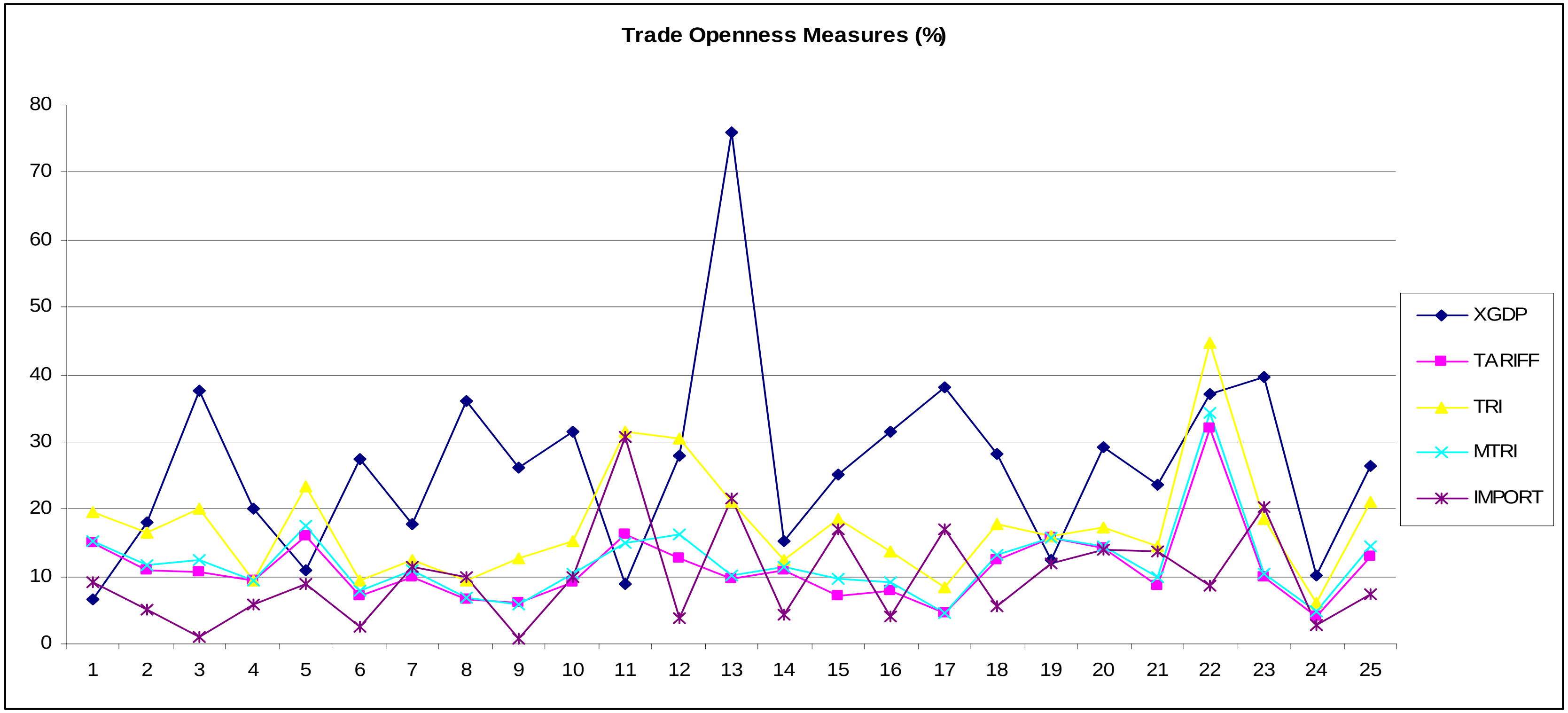
[8] Please see the appendix for an elaboration of this point.

Table 1
Raw Data

Country	*TARIFF*	*XGDP*	*TRI*	*MTRI*	*IMPORT*	*POP*	*PGDP*	*AREA*
Argentina	14.9	6.598187	19.6	15.3	9.11	33400.41	8808.67	2766890
Australia	10.8	18.04171	16.6	11.6	5.1	17489	20165.06	7686850
Austria	10.6	37.60335	20	12.4	1.09	7913.8	20431.42	83870
Bolivia	9.4	20.04576	9.3	9.3	5.73	6897	2447.57	1098580
Brazil	16.1	10.86825	23.3	17.6	8.83	152680	6104.5	8511965
Canada	7.0	27.35862	9.5	7.9	2.44	28376.5	21195.1	9984670
Colombia	10	17.70846	12.4	10.9	11.44	36363.42	4955.32	1138910
Ecuador	6.5	36.02702	9.5	6.9	9.9	10735.02	3821.63	283560
Finland	6.0	26.20618	12.6	5.9	0.75	5042	17693.5	337030
Hungary	9.1	31.445	15.3	10.3	9.97	10324	8250.68	93030
India	16.2	8.994515	31.6	15.1	30.74	882300	1723.68	3287590
Indonesia	12.8	27.89144	30.4	16.2	3.79	184556.2	3169.43	1919440
Malaysia	9.7	75.98386	21.0	10.2	21.67	19127.1	6963.64	329750
Mexico	10.8	15.23779	12.4	11.4	4.29	86238	7616.05	1972550
Morocco	7.1	25.07515	18.5	9.7	16.89	24999.43	3506.31	446550
New Zealand	7.9	31.4844	13.6	9.1	4.05	3514	15206.32	268680
Norway	4.5	37.97216	8.4	4.6	17.02	4286	21389.65	324220
Paraguay	12.5	28.07129	17.8	13.2	5.53	4470.35	5050.62	406750
Peru	15.8	12.51906	16.0	15.8	11.86	22369.07	3646.15	1285220
Philippines	14.2	29.12975	17.3	14.6	14.02	65559.68	2880.58	300000
Poland	8.7	23.70006	14.5	9.8	13.6	38364.7	6221.99	312685
Thailand	32	36.97248	44.7	34.4	8.66	57343.26	5459.93	514000
Tunisia	9.9	39.5348	18.6	10.4	20.36	8514.7	5196.97	163610
USA	4.0	10.18557	6.1	4.8	2.78	255403	26460.18	9631418
Venezuela	12.9	26.35527	21.1	14.5	7.3	20441	7137.19	912050

Sources: AN (2003), Yanikkaya (2003), World Bank (devdata.worldbank.org/dataonline), CIA world fact-book (cia.gov)
Population (POP): '000 (1992), Per Capita GDP (PGDP): constant 1995 US$, Area: sq. km., Distance to Equator: km.

Figure – 1



Sources: AN (2003), Yanikkaya (2003)

Note: *Import* data represents the average for the 1990s, *XGDP* data correspond to the year 1992. For *Tariff*, *TRI* and *MTRI*, data from the following years are available:

1984 – Morocco
1988 – Norway, Finland, New Zealand, Malaysia, Austria, Australia, Thailand,
1989 – Poland, Mexico, Indonesia, Brazil
1990 – USA, Canada, Paraguay,
1991 – Ecuador, Hungary, Bolivia, Tunisia, Colombia, Venezuela, Philippines, Peru, India,
1992 – Argentina

5. Concluding Remarks

This paper employed some new and traditional measures of trade restrictiveness to asses the relationship between country size and openness. We found that the inverse relationship between openness and country size as reported in Alesina et. al (1998) holds true for the cross country sample of 25 nations considered. Despite the limitations of the TRI and MTRI discussed in section 4, they remain the best theoretical indices of protectionism so far. Future research along these lines will make use of a larger and much more comprehensive data set that not only incorporates many more countries but also panel data across time. It would be interesting to repeat this exercise using the UTDE measure proposed by DT (2004). However, we do not expect the qualitative results to change.

Appendix: The non-existence and non-uniqueness of the TRI when countries are large.

Dhaklia and Temimi (DT, 2004) have cast doubt upon the existence and uniqueness of the TRI especially when countries are large. We recall that the construction of the TRI requires us to find the Uniform Tariff Equivalent (UTE) – the ad-valorem tariff rate that when applied to all imports yields the same welfare loss as the actual system of ad-valorem tariffs. The UTE is illustrated in Figure 2.

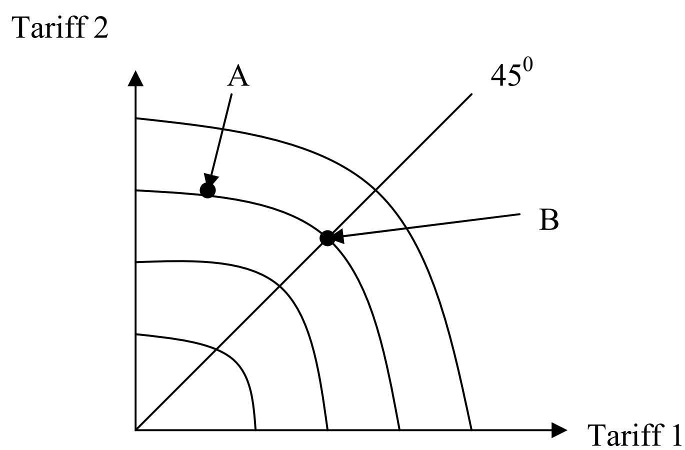


Figure 2: The UTE

Figure 2 shows a country's welfare level curves with respect to ad-valorem tariff rates on two goods. If the actual tariff structure is represented by point A, then point B represents the uniform tariff rate vector with the same negative welfare effect.

DT contend that the above mentioned approach must necessarily assume that the country in question is small. A large country may have a non-zero optimal tariff and the welfare effects would then no longer be monotonic over the set of positive tariffs. Consequently if the small country assumption is dropped, the UTE would either not exist or would assume multiple values. The intuition behind this idea is illustrated as follows.

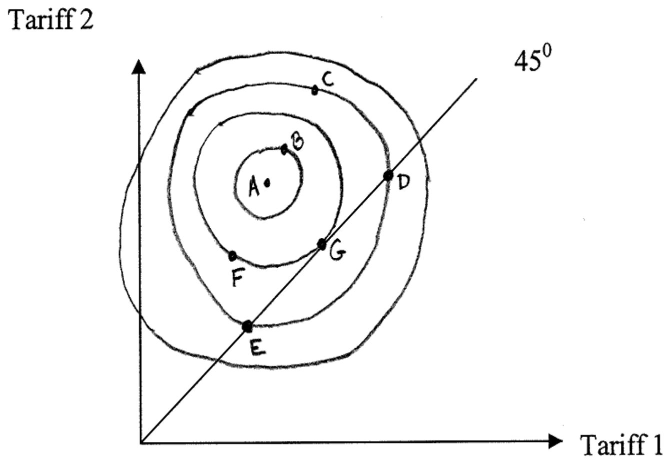


Figure 3: The non-existence or multiplicity of a UTE

In the large country case, let the welfare-maximizing tariff vector, represented by point A, be in the positive orthant and the iso-welfare curves be concentric around this optimum (for purposes of exposition it is assumed that the iso-welfare curves are well behaved and point A is the only local welfare maximum, in other words the construction is free of "pathologies"). Three possible cases emerge.

First, if the actual tariff vector is given by point B, located on an iso-welfare curve that does not intersect the 45 degree line, a UTE does not exist.

Second, if the actual tariff is given by point C, located on an iso-welfare curve that intersects the 45 degree line at points D and E, multiple UTEs exist.

Third, if the actual tariff is given by point F, then the UTE will be at point G. This however seems to be coincidental.

The source of the problem, once again, is that the welfare of a large country is not monotonic in uniform tariffs. SD suggest an alternative measure of protection, namely the Uniform Tariff Deviation Equivalent (UTDE) wherein the benchmark used to measure the cost of protection is no longer (deviation from) free trade (as is the case for the TRI and MTRI) but some welfare maximizing tariff vector.

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